HEWLETT-PACKARD COMPANY / OPERATING AND SERVICE MANUAL

302A

WAVE ANALYZER

302A

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OPERATING AND SERVICE MANUAL

MODEL 302A

SERIALS PREFIXED: 018 -

WAVE ANALYZER

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Table 1-1. Specifications

Frequency Range:
20 cycles to 50,000 cycles

Frequency Calibration:
Linear graduation 1 division per 10 cycles

Dial Accuracy:
± (1% + 5 cps)

Voltage Range:
30 microvolts to 300 volts full scale, 15 ranges in a 30, 100, 300 sequence. Ranges provided by input attenuator and a meter range switch in steps of 1:3 or 10 db. Meter range is indicated by a dial mechanically linked with the input attenuator. An absolute-relative switch, in conjunction with a variable 10 db control is provided for adjustment of intermediate values.

Warmup Time:
None

Voltage Accuracy:
±5% of full scale value

Residual Modulation Products and Hum Voltage:
Greater than 75 db down

Intermediate Frequency Rejection:
Intermediate frequency present in input signal rejected by at least 75 db

Selectivity:
±3-1/2 cycle bandwidth at least 3 db down;
±25 cycle bandwidth at least 50 db down;
±70 cycle bandwidth at least 80 db down;
beyond ±70 cycle bandwidth at least 80 db down.

Input Impedance:
Determined by setting of input attenuator: 100,000 ohms on four most sensitive ranges, 1 megohm on remaining ranges.

Restored Frequency Output:
1 volt across 600 ohms at output terminals for full scale meter deflection; output voltage proportional to meter reading. Output level control provided. Frequency response ±2%, 20 cycles to 50,000 cycles. Output impedance approximately 600 ohms.

Oscillator Output:
1 volt across 600 ohms at output terminals (mode selector in B. F. O.). Output level control provided. Frequency response ±2%, 20 cycles to 50,000 cycles. Output impedance approximately 600 ohms.

Recorder Output:
1 ma dc into 1500 ohms or less at full scale meter indication; for ungrounded recorders only.

Automatic Frequency Control:
Range of frequency hold-in is ±100 cps minimum.

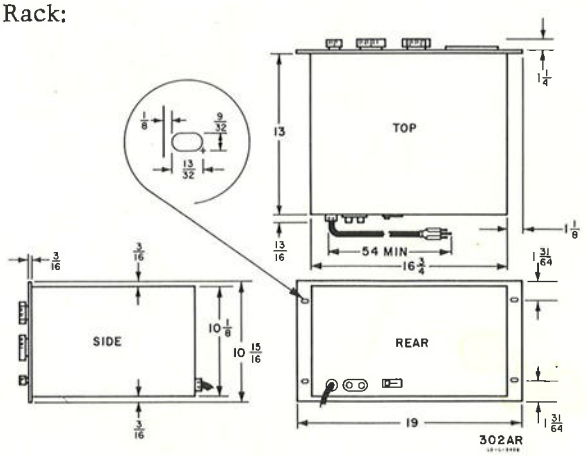
Power:
115 or 230 volts ±10%, 50 to 1600 cycles, 3 watts (approximately). Terminals are provided for powering instrument from external battery source. Battery supply range 28 to 18 volts.

Weight:
Cabinet: Net 43 lbs, shipping 54 lbs

Rack: Net 35 lbs, shipping 50 lbs

Dimensions:
Cabinet: 20-3/4 in. wide, 12-1/2 in. high, 14-1/2 in. deep

Rack:



SECTION I
GENERAL DESCRIPTION

1-1. INTRODUCTION.

1-2. The hp Model 302A Wave Analyzer is a tunable voltmeter of high selectivity and high sensitivity covering the frequency range of 20 cps to 50 kc. The frequency scale is linear throughout the band with a constant resolution of one division per 10 cps.

1-3. The instrument separates an input signal into its individual frequency components so that fundamental harmonic and intermodulation products may be separately measured and evaluated. It may also be used as a narrow-band tuned voltmeter which will read absolute or relative levels.

1-4. An automatic frequency control (afc) circuit locks the measuring system to the frequency of the incoming signal, thus eliminating the need for frequency tracking while making a measurement.

1-5. Absolute voltage measurements are made directly with the SCALE VALUE switch in ABSOLUTE. In the RELATIVE position a reference level can be established (fundamental component) and the amplitude of the higher order harmonic components is expressed in percent or decibels. The operation of the instrument is simple; it requires no tune-up procedures and all controls are direct reading.

1-6. Besides its primary function as a waveform analyzer the Model 302A can be operated as an oscillator-tuned voltmeter combination. In BFO operation an oscillator and the tuned voltmeter track together over the entire frequency range (20 cps to 50 kc) of the Model 302A. Since one control tunes both the oscillator and the voltmeter simultaneously, measurements of filter and amplifier responses are simple. Further, since the tuned voltmeter has a very narrow pass band, noise and harmonics of the signal have negligible effect on the meter reading even at low levels.

1-7. OUTPUT SIGNALS.

1-8. The instrument provides either of two output signals, depending on the operation mode, and a dc output for operating a recorder.

1-9. RESTORED FREQUENCY OUTPUT.

1-10. With the MODE SELECTOR switch in position AFC or NORMAL an output signal is obtained whose

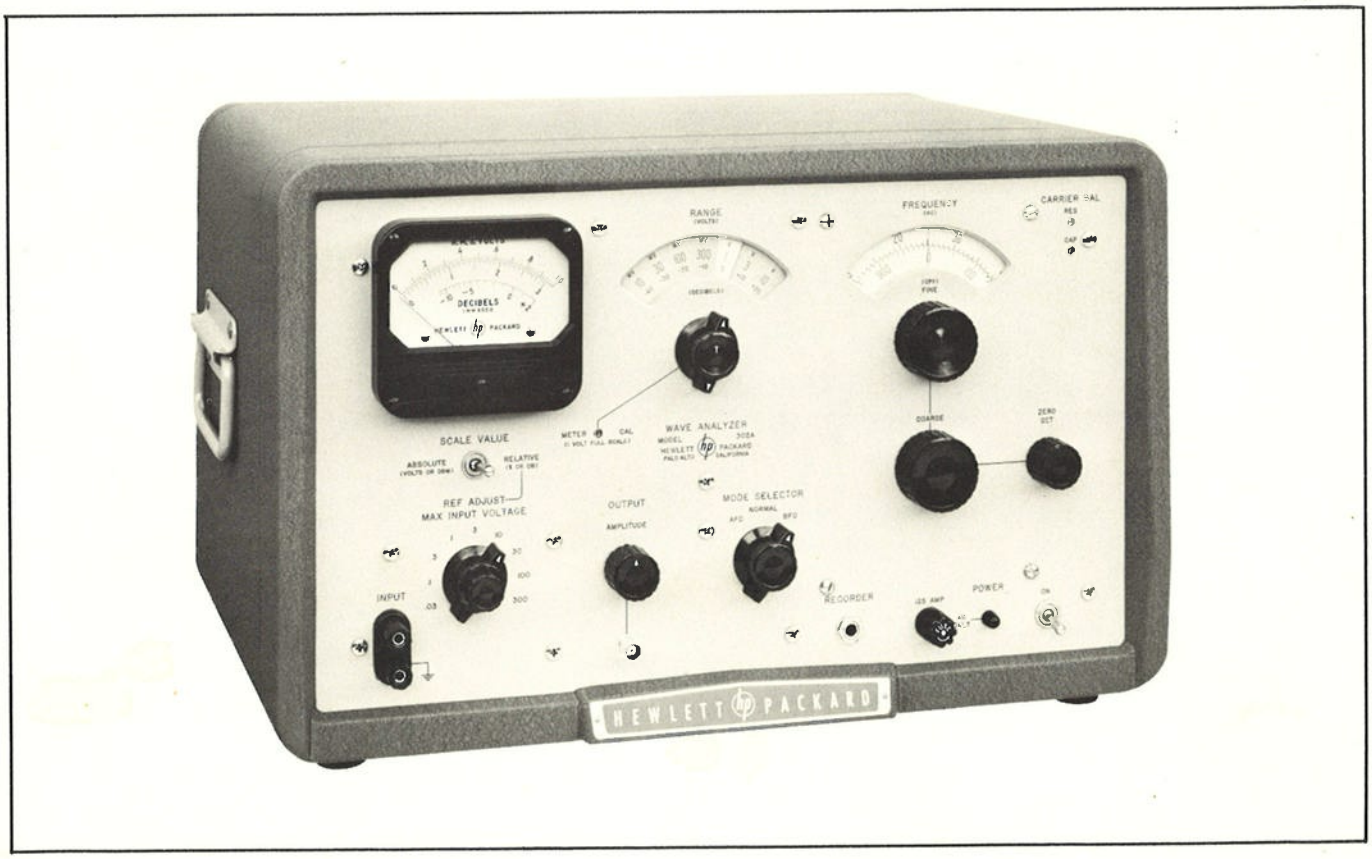


Figure 1-1. Model 302A Wave Analyzer

frequency is the restored frequency of the input signal. Thus where complex or non-harmonically related components are being investigated an external counter can be used to measure the selected component frequency with high accuracy.

1-11. SELECTED FREQUENCY OUTPUT.

1-12. In BFO operation the instrument delivers an output signal whose frequency is selected and indicated by the FREQUENCY dial. The output level is continuously adjustable and held constant across the entire frequency range. The wave analyzer thus becomes an audio signal generator combined with a tuned voltmeter.

1-13. RECORDER OUTPUT.

1-14. A phone jack recorder output enables the connection of a graphical recorder in series with the panel meter movement. The recorder input must be isolated from ground and have an input impedance not exceeding 1500 ohms. A dc current of 1 ma produces a full scale meter deflection.

SECTION II
INSTALLATION

2-1. UNPACKING AND INSPECTION.

2-2. Unpack and inspect the Model 302A as soon as possible after receipt. Save the packing materials until the inspection is complete, for these materials may be needed for reshipment in the event of shipping damage.

2-3. Inspect the Model 302A for signs of physical damage such as a scratched panel, broken knobs, etc. The front panel performance check (paragraph 5-13) may be used to check the Model 302A for normal operation. If there is any damage, file a claim with the carrier. Refer to the warranty page at the rear of this manual.

2-4. REPACKAGING FOR SHIPMENT.

2-5. The following is a general guide for repackaging an instrument for shipment. If you have any questions, contact your authorized Hewlett-Packard sales office.

a. If possible, use the original container designed for the instrument.

b. Wrap the instrument in heavy paper or plastic before placing it in the shipping container.

c. Use plenty of packing material around all sides of the instrument and protect panel faces with cardboard strips.

d. Use a heavy cardboard carton or wooden box to house the instrument and use heavy tape or metal bands to seal the container.

e. Mark the packing box with "Fragile", "Delicate Instrument", etc. as appropriate.

Note

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach to the instrument a tag identifying the owner and indicating the service or repair to be accomplished. In any correspondence, identify the instrument by model number, serial number, and serial number prefix.

2-6. RACK MOUNTING.

2-7. The 302A may be mounted in a standard 19-inch rack. With the cabinet removed, the instrument is ready for rack mounting. See paragraph 5-9 for cabinet removal.

2-8. THREE-CONDUCTOR POWER CABLE.

2-9. For the protection of operating personnel, National Electrical Manufacturers' Association (NEMA) recommends that all electrical instruments (chassis, exposed parts, etc.) be grounded by a special conductor. All Hewlett-Packard instruments are equipped with a three-conductor power cable terminated with a three-prong connector. The offset pin is the ground contact.

2-10. Use a three-prong to two-prong adapter when operating the instrument from a two-contact outlet. Ground the instrument externally with the green pigtail on the adapter.

2-11. 230-VOLT OPERATION.

2-12. The Model 302A Wave Analyzer can easily be converted to operate from a nominal 230 volt, 50 to 1600 cps source. The conversion is made on a tie strip located near the power transformer. See paragraph 5-11 for details.

2-13. EXTERNAL BATTERY OPERATION.

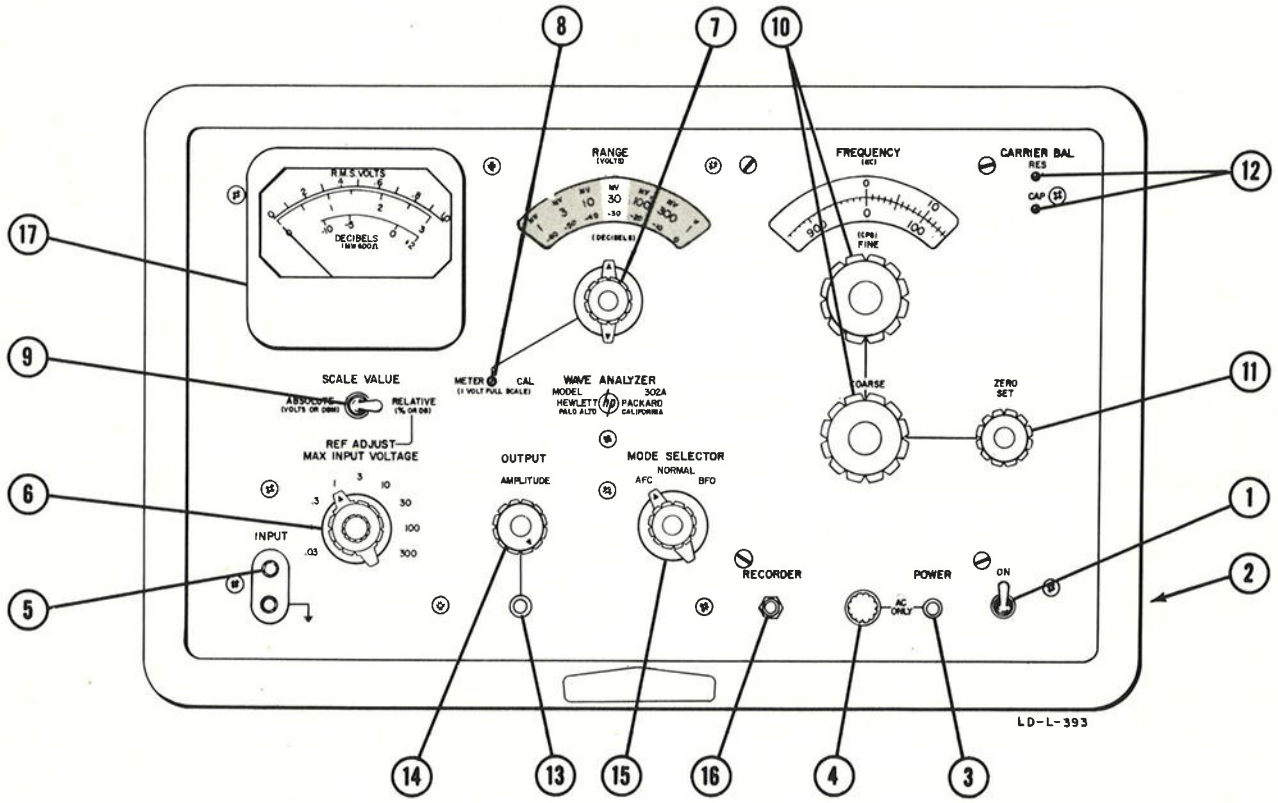
2-14. The instrument can be operated from an external dc source of 18 to 28 volts, with current requirements of approximately 70 ma. Binding post terminals are provided at the rear of the instrument for battery connection. The slide switch located next to the binding post terminals changes the power source circuitry for battery operation.

CAUTION

The positive (red) terminal is grounded to the chassis and cabinet. The external dc supply should preferably be floating, otherwise a short circuit may damage the external wiring. It is suggested that both sides of the supply be fused at 1 ampere maximum when using a dc supply other than dry cell batteries.

2-15. INCOMING QUALITY CONTROL INSPECTION.

2-16. The accuracy check (paragraphs 5-15 through 5-18) may be used as a part of your incoming quality control inspection.



1. POWER ON switch (ac power only).
2. AC-BATTERY selector (rear of instrument).
3. Pilot light, monitoring ac input power only.
4. AC fuse, 0.125 ampere.
5. Input signal terminals, for signals of 20 cps to 50 kc and maximum amplitude as selected by MAX. INPUT VOLTAGE selector.
6. MAX. INPUT VOLTAGE switch; input attenuator having 9 positions for a maximum input voltage range from 300 volts to 30 millivolts, the selected range being indicated with dial of RANGE switch.
7. RANGE switch, indicated by window position, highest voltage level indicated being maximum input voltage; range: 60 db in six 10 db steps. RANGE switch dial mechanically coupled with MAX. INPUT VOLTAGE switch.
8. Meter calibration adjustment with RANGE switch on position METER CAL (figure 3-2).
9. SCALE VALUE selector switch in ABSOLUTE position, meter readings are absolute with reference to the window of RANGE switch. In RELATIVE position, intermediate values can be adjusted with vernier of MAX. INPUT VOLTAGE switch.
10. FREQUENCY selector, 20 cps to 50 kc, 10 cps per 1 division, dial accuracy ± (1% + 5 cps).
11. ZERO SET adjustment for frequency dial calibration (see figure 3-2).
12. CARRIER BAL adjustment (see figure 3-2).
13. OUTPUT signal connector, providing a maximum signal of at least 1.0 volt across 600 ohms, of the restored input signal frequency (on AFC and NORMAL) or the selected frequency (BFO).
14. Output signal AMPLITUDE control.
15. MODE SELECTOR switch. On AFC mode, the tuned circuits are locked to the input signal frequency, on NORMAL mode the afc circuits are disconnected, on BFO the instrument provides output signal corresponding to the frequency indicated on the FREQUENCY dial.
16. Recorder output for 1 ma dc (full scale deflection) into 1500 ohms, for non-grounded recorder only.
17. Front panel meter calibrated in 0-1.0 (0-100%), 0-3 (0-30%) and -12 to +2 db.

Figure 3-1. Operating Controls

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. This section contains all information necessary to operate the Model 302A Wave Analyzer. If the instrument is operated for the first time follow paragraphs 3-4 through 3-36 in that order.

3-3. Fundamental measurements with the Model 302A are described in paragraphs 3-12 and 3-23. A number of applications for the instrument are given in paragraph 3-39.

3-4. OPERATING ADJUSTMENTS.

3-5. ZERO-SETTING METER. The meter pointer must rest on the zero calibration mark on the meter scale when the instrument 1) is at normal operating temperature, 2) is in its normal operating position, and 3) is turned off. To zero-set the meter proceed as follows:

a. Turn instrument off. Wait a few minutes for power-supply capacitors to discharge completely.

b. Rotate adjustment screw on meter panel clockwise until meter pointer is to the left of zero and further clockwise rotation will move pointer upscale toward zero.

c. Turn adjustment screw clockwise until pointer is exactly over zero mark on scale. If screw is turned too far, repeat steps b and c.

d. Turn meter adjustment screw counterclockwise about 5 degrees, but not far enough to move meter pointer back downscale. If screw is turned too far, repeat procedure.

3-6. The meter is now zero-set for best accuracy and mechanical stability.

3-7. BATTERY AC-SWITCH. Set the slide switch, located at rear of instrument, for AC or BATTERY operation as desired.

3-8. INSTRUMENT TURN-ON.

3-9. The instrument is now ready to be turned on. Refer to figure 3-1, Operating Controls, since there is no turn-on procedure to be followed.

3-10. CALIBRATION.

3-11. Before making any measurement, calibrate the instrument. The calibration consists of three procedures: 1) Carrier Zero Set, 2) Carrier (Modulator) Balance, and 3) Meter Calibration. The three calibration procedures are shown in figure 3-2.

3-12. ABSOLUTE AMPLITUDE MEASUREMENT.

3-13. The procedure to measure the amplitude of an incoming signal is given in figure 3-3.

3-14. The amplitude of the harmonic component of a complex waveform can be measured and expressed in either absolute terms (volts) or relative terms (% or db).

3-15. In absolute measurements the amplitudes of the harmonic components of a signal are obtained in absolute values (volts). The procedure is the same as described in figure 3-3 with the following addition:

3-16. FUNDAMENTAL FREQUENCY MEASUREMENT.

3-17. Set RANGE window fully clockwise. From its extreme clockwise position, rotate MAX. INPUT VOLTAGE switch counterclockwise to obtain highest on-scale (= reference) value.

3-18. HARMONIC COMPONENT MEASUREMENT.

3-19. Tune Model 302A to frequency of desired harmonic component. Without changing the position of the MAX. INPUT VOLTAGE switch rotate the RANGE switch counterclockwise for optimum meter reading.

3-20. The above procedure provides a 72 db range for any setting of the MAX. INPUT VOLTAGE switch. 60 db (RANGE switch) + db-range on meter (approximately 12 db) = approximately 72 db.

3-21. AMPLITUDE EXPRESSED IN VOLTS.

3-22. The position of the RANGE switch window determines the full scale reading of the meter. Read:

Top Scale (0 - 1.0) for 10 v, 1 v, 100 mv, etc.
Center Scale (0 - 3) for 3 v, 300 mv, 30 mv, etc.

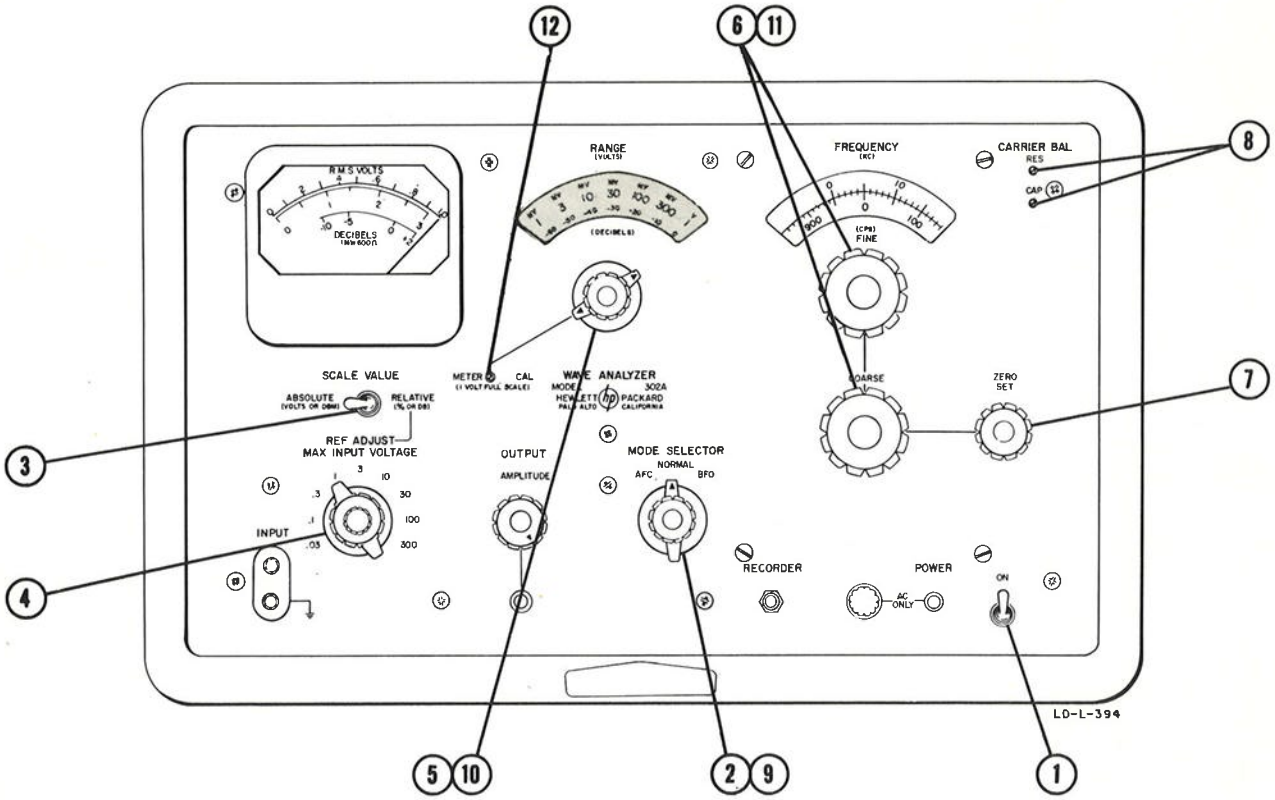
3-23. AMPLITUDE EXPRESSED IN DECIBELS.

3-24. The decibel is used to express the ratio of two power levels. However, the db unit may also be used to express voltage ratios, provided the impedances are taken into account. The ratio of the two power levels is expressed as:

$$\frac{P_1}{P_2} = \frac{E_1^2}{E_2^2} \times \frac{R_2}{R_1} \quad \text{or:}$$

$$10 \times \log \left(\frac{P_1}{P_2}\right)_{db} = 20 \times \log \left(\frac{E_1}{E_2}\right)_{db} \text{ for } R_1 = R_2$$

Thus a voltage ratio of 20 db expresses a power ratio of 10 db when the voltages are measured across the same impedance.



CARRIER ZERO SET (100 kc)

1. Turn on instrument.
2. Set MODE SELECTOR to NORMAL.
3. Set SCALE VALUE to ABSOLUTE.
4. Set MAX INPUT VOLTAGE to "1".
5. Set RANGE (window) to 30 MV.
6. Set FREQUENCY dial to 0.0 KC.
7. Adjust ZERO SET for maximum meter reading.

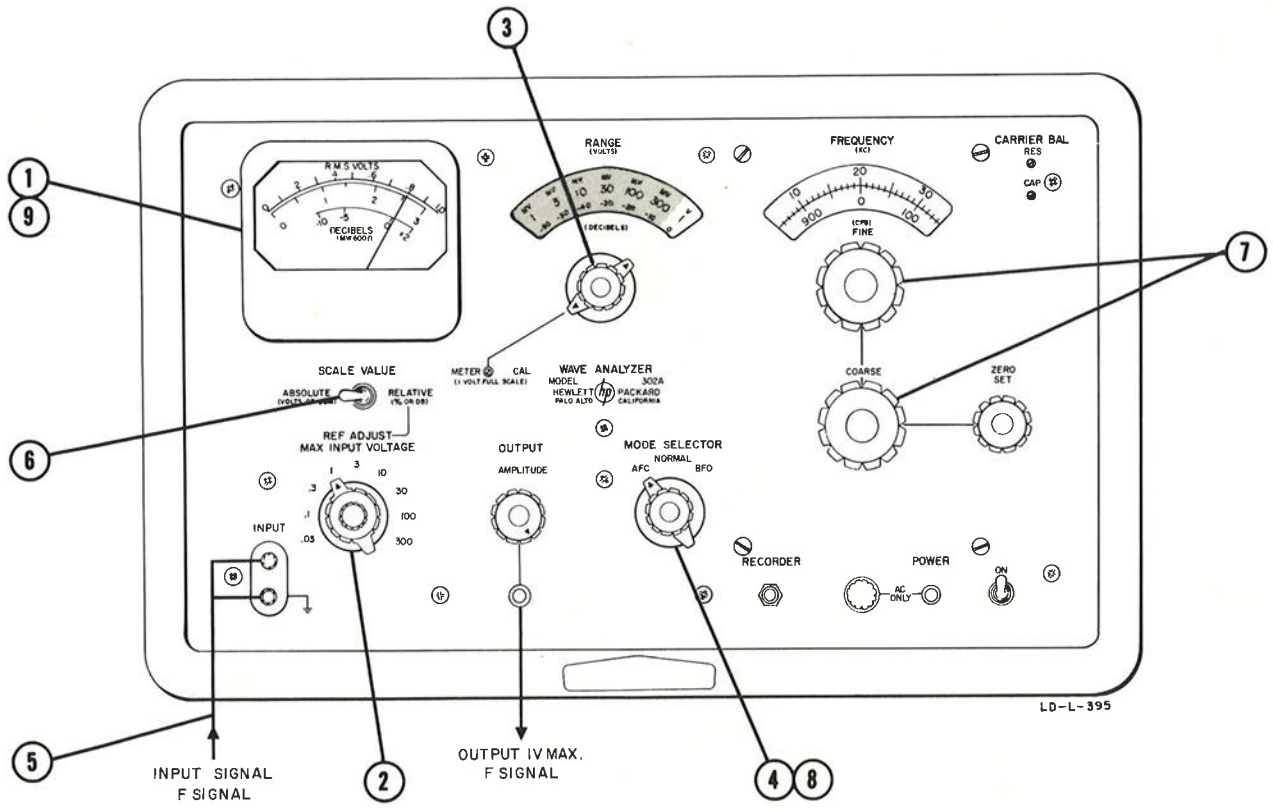
CARRIER BALANCE (100 kc)

8. Adjust CARRIER BAL for minimum reading; RES and CAP adjustments are interacting. Maximum reading should be -40 db or less.

METER CALIBRATION (1.0 v)

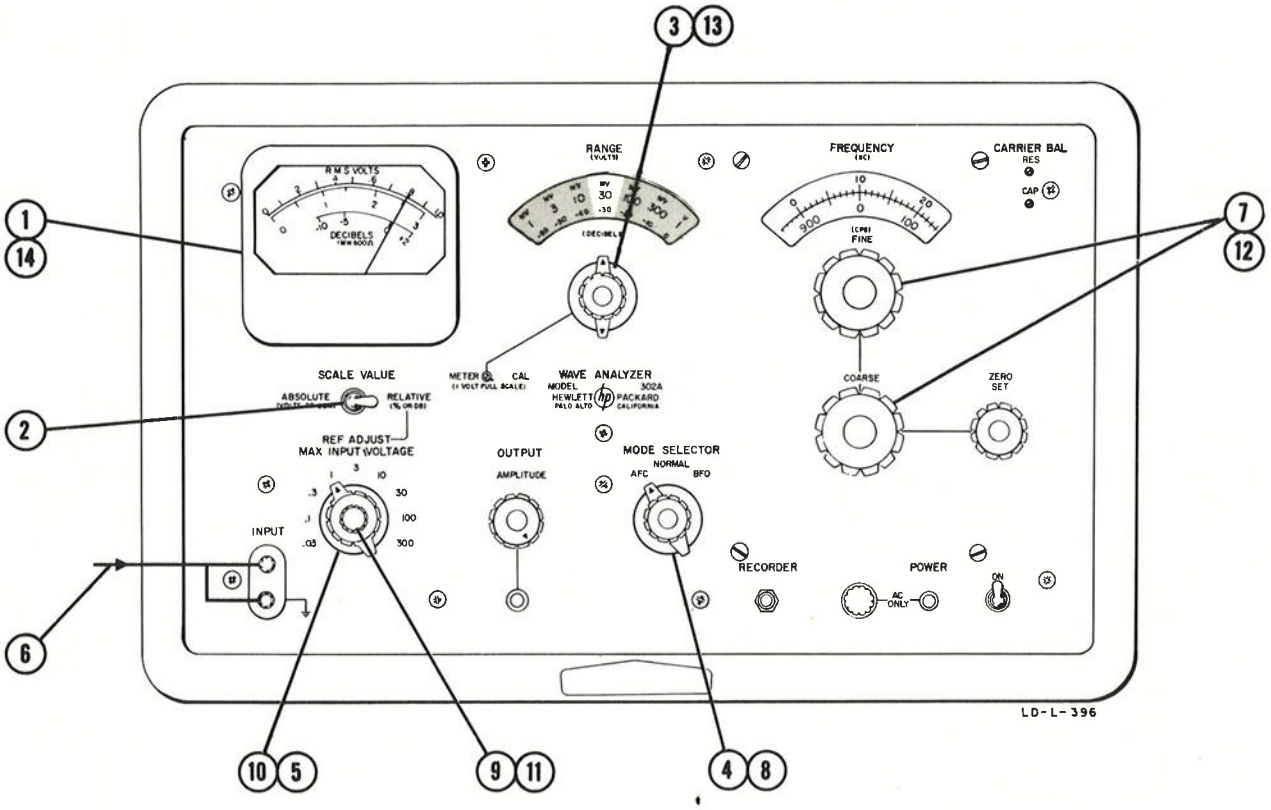
9. Set MODE SELECTOR to NORMAL position.
10. Rotate RANGE switch to METER CAL position (full clockwise).
11. Tune FREQUENCY dial to calibrator frequency, which is between 4-5 kc. Switch MODE SELECTOR to AFC.
12. Turn METER CAL adjustment for 1.0 volt meter reading.

Figure 3-2. Calibration



1. Calibrate instrument as indicated in figure 3-2.
2. Set MAX. INPUT VOLTAGE to level higher than or equal to the expected input signal level.
3. Set RANGE switch (window) fully clockwise (reading coinciding with position of MAX. INPUT VOLTAGE control).
4. Set MODE SELECTOR to NORMAL.
5. Connect input signal to INPUT terminal.
6. Set SCALE VALUE switch to ABSOLUTE.
7. Tune Wave Analyzer to frequency of input signal. Adjust MAX. INPUT VOLTAGE switch for highest on-scale reading.
8. Set MODE SELECTOR to AFC.
9. Read amplitude of input signal.

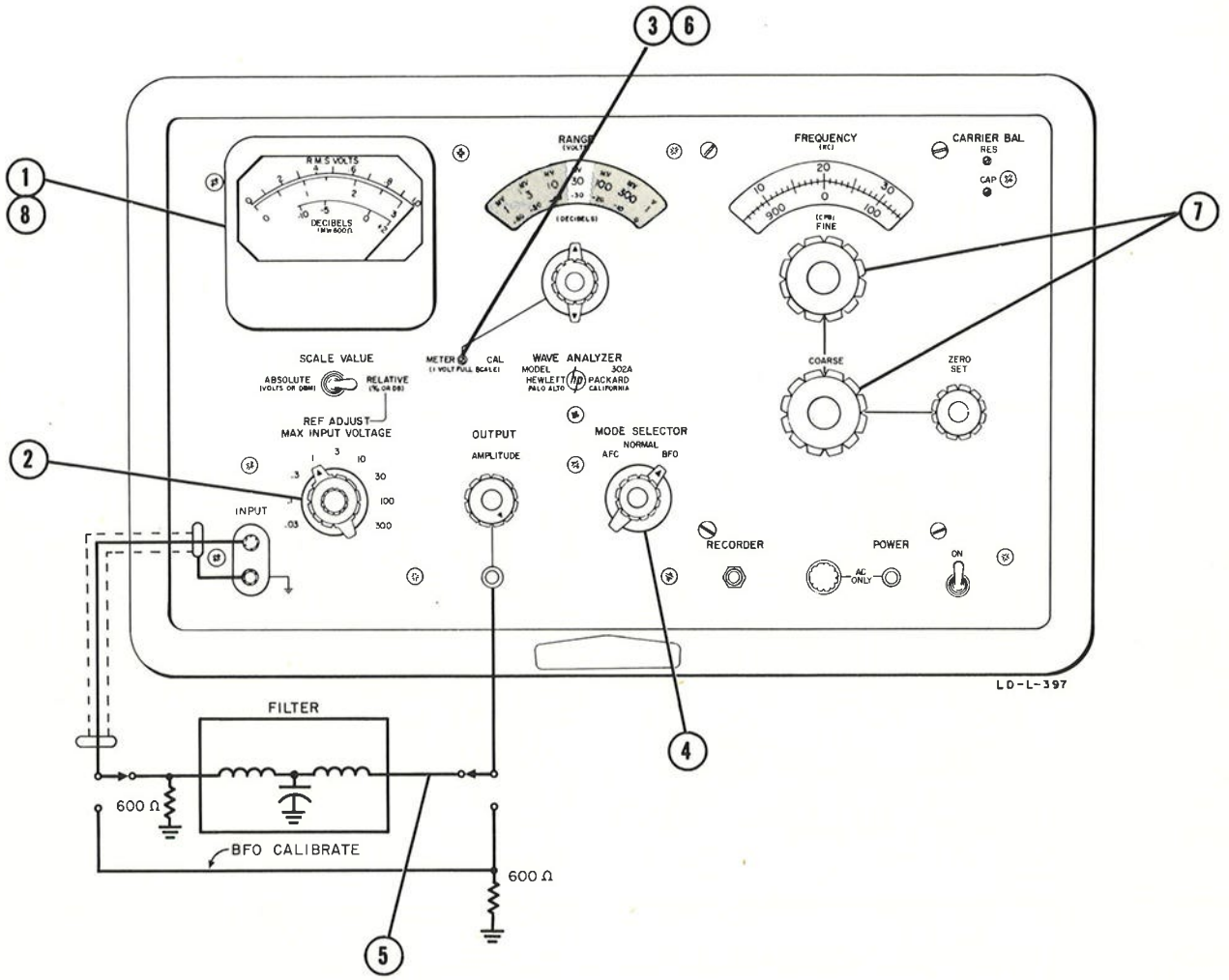
Figure 3-3. Absolute Amplitude Measurement



1. Calibrate instrument as indicated in figure 3-2.
2. Set SCALE VALUE selector to RELATIVE.*
3. Set RANGE switch "window" fully clockwise.
4. Set MODE SELECTOR to NORMAL.
5. Set MAX. INPUT VOLTAGE to value higher than or equal to expected amplitude of fundamental signal component.
6. Connect signal to INPUT.
7. Tune wave analyzer to frequency of fundamental component.
8. Switch MODE SELECTOR to AFC.
9. Reduce gain with REF ADJUST control for meter reading which is approximately 0.23 (read on upper scale) or -10 db (read on db scale).
10. Rotate MAX. INPUT VOLTAGE switch counterclockwise by one position.
11. Adjust REF ADJUST gain control for 1.0 (100%) or 0 db (read on db scale).
12. Tune wave analyzer to harmonic frequency.
13. Rotate RANGE switch counterclockwise to increase sensitivity (DO NOT CHANGE MAX. INPUT VOLTAGE SWITCH SETTING).
14. Read amplitude of harmonic component in % or db (see paragraph 3-24).

* Harmonic measurements can also be made with the SCALE VALUE selector in ABSOLUTE. Omit steps 9 through 11 of procedure and read harmonic amplitudes in absolute values.

Figure 3-4. Harmonic Measurements



1. Calibrate instrument as indicated in figure 3-2.
2. Set MAX. INPUT VOLTAGE switch to 1 volt.
3. Set RANGE switch (window) to 1 volt.
4. Set MODE SELECTOR to BFO.
5. Connect network under test (filter, etc.) to BFO OUTPUT and signal INPUT terminals.
6. Rotate RANGE switch counterclockwise until meter reading is within -12 db to +2 db range.
7. Measure frequency response.
8. Attenuation value is obtained by adding the meter reading to the db of attenuation removed by RANGE switch.

Figure 3-5. BFO Operation

3-25. The amplitude of a signal developing 1 milliwatt in 600 ohms is 0.775 volt. This level is defined as 0 dbm. A 3:1 voltage ratio corresponds to a power level change of approximately 10 db, and a 10:1 voltage ratio to 20 db, etc. The dbm value of the input signal is obtained by adding the bottom meter scale reading (-12 db to +2 db) and the RANGE switch reading (window at +20 dbm for 10 volts, +10 dbm for 3 volts, etc.).

Example: What dbm reading corresponds to 1.5 volt amplitude across 600 ohms?

$$2 \times 10 \log \left(\frac{1.5}{0.775}\right) \text{ db} = 2 \times 2.87 = 5.74 \text{ dbm}$$

1.5 volt across 600 ohms corresponds to +5.74 dbm

Reading of RANGE switch dial (window) = +10 db (dbm)

Reading of bottom meter scale = - 4.26 db

Total reading: +10 dbm +(-4.26) db = +5.74 dbm

3-26. RELATIVE AMPLITUDE MEASUREMENTS.

3-27. In relative harmonic measurements the amplitude of the harmonic component is expressed in terms of the amplitude of the fundamental component. Refer to figure 3-4 for the measurement procedure.

3-28. Basically the gain of the wave analyzer is adjusted so that the amplitude of the fundamental component is indicated as 0 db or 100%. Without changing the MAX. INPUT VOLTAGE switch position the harmonic components are expressed in % or db with respect to the fundamental component. Required sensitivity is obtained by operating the RANGE switch.

3-29. HARMONIC AMPLITUDE EXPRESSED IN %.

3-30. After completion of steps 1 through 11 in figure 3-4, the wave analyzer is tuned to the 2nd, 3rd ... harmonic frequency. Switch MODE SELECTOR to NORMAL while tuning, and to AFC for the amplitude measurement. Rotate RANGE switch counterclockwise to remove attenuation at the IF amplifier input.

Note

Values in the 100%, 10%, 1% ... full-scale range are read on upper meter scale. Values in the 30%, 3%, 0.3% ... full-scale range are read on the center meter scale.

3-31. HARMONIC AMPLITUDE EXPRESSED IN DB.

3-32. The amplitude of the harmonic components of a signal can also be measured and expressed in decibels below a reference level.

3-33. The procedure is analogous to the harmonic measurement expressed in %. Complete steps 1 through 11 of figure 3-4. Tune to higher order harmonics (MODE SELECTOR in NORMAL position while tuning, in AFC for the measurement).

3-34. The amplitude of the harmonic component is obtained by adding the meter reading (-12 db to +2 db) to the db reading of the RANGE switch (window).

3-35. BFO OPERATION.

3-36. In the BFO operation the wave analyzer generates a signal whose frequency corresponds to the value selected by the FREQUENCY dial of the instrument. The operating procedure is given in figure 3-5.

3-37. APPLICATIONS.

3-38. There are three basic applications for the Model 302A Wave Analyzer:

3-39. TUNED VOLTMETER.

3-40. The tuned voltmeter is used for determining amplitude, distortion, frequency spectrum, loop gain, etc.

3-41. FREQUENCY SPECTRUM MEASUREMENT. The amplitude distribution over the entire frequency

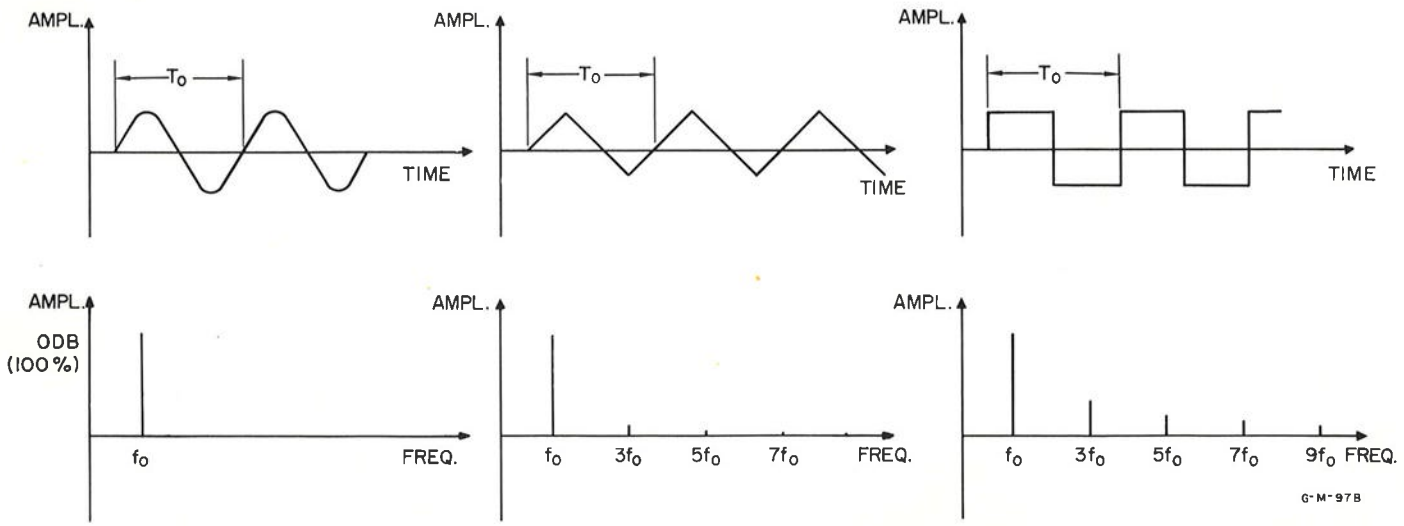


Figure 3-6. Typical Frequency Spectra

range of a periodic signal is known as its frequency spectrum. A complex waveform having higher order harmonics not exceeding 50 kc can be analyzed directly by measuring the harmonic frequency components individually. Figure 3-6 shows typical frequency spectra for different periodic signals.

3-42. The instrument has a maximum sensitivity of 30 microvolts full scale and is capable of measuring harmonic signals with levels as low as -90 dbm. Since the Model 302A has a very high selectivity, measurements become difficult when the input signal frequency has a tendency to drift. However, the AFC-mode of operation eliminates the need for tracking, since the local oscillator is automatically locked to the signal frequency. The local oscillator is able to follow slow drift excursions as far as ±100 cps from the set frequency.

3-43. Use of the Model 302A in a setup where the frequency spectrum is automatically measured and displayed is shown in figure 3-7. The Model 302A is automatically tuned throughout a frequency range by ℗ AC-97C (℗ 297A) Sweep Drive. A frequency analog output of the AC-97C (℗ 297A) and the RECORDER output of the Model 302A are fed to the X-Y input of the recorder. A slow sweeping speed allows true amplitude readings to be made.

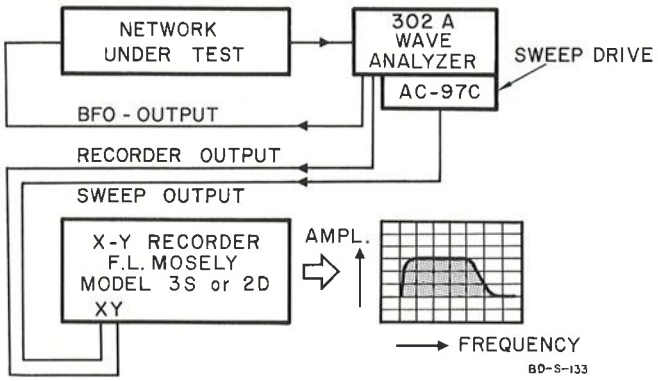


Figure 3-7. Automatic Spectrum Reading

3-44. HARMONIC DISTORTION MEASUREMENT. Nonlinear distortions of amplifiers can be determined by measuring the frequency spectrum of the amplifier output when feeding a single frequency signal to the amplifier input. A low-distortion input signal is obtained by using a low-pass filter as shown in figure 3-8. The distortion factor is then computed:

$$d = \sqrt{\frac{a_2^2 + a_3^2 + \ldots a_n^2}{a_1^2}} \times 100$$

where: a_1 = amplitude of the fundamental

a_2, a_3, etc. = amplitude of harmonic components

d = distortion in %

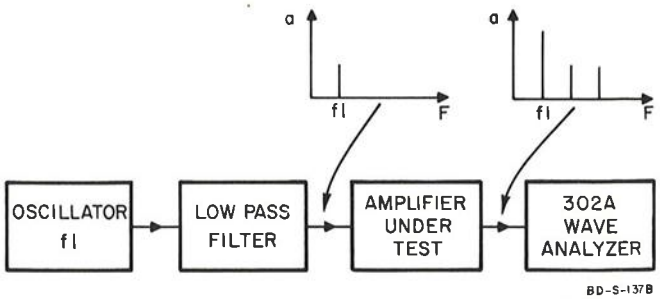


Figure 3-8. Harmonic Distortion Measurement

3-45. INTERMODULATION DISTORTION MEASUREMENT. The distortion of an amplifier can be measured by using the intermodulation method. In this method, two signals of different frequency are applied simultaneously to the input of an amplifier (figure 3-9).

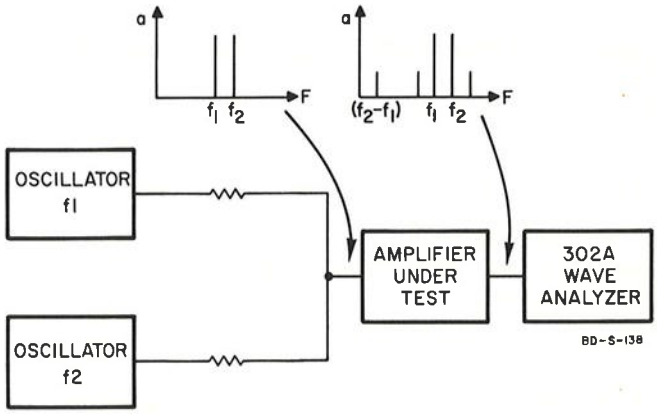


Figure 3-9. Intermodulation Distortion Measurement

3-46. If the amplifier has a nonlinear transfer characteristic, the frequency spectrum of the amplifier output will contain sideband components. These sideband components are produced by the intermodulation of the two input signals, similar to the modulation of a carrier signal by its modulation signal.

3-47. One method to determine the intermodulation factor is suggested by the CCIF (International Telecommunications Commission) using two input signals of equal amplitude and having a frequency relationship as indicated in figure 3-10.

3-48. Three selective amplitude measurements supply the amplitude components necessary to determine the intermodulation factor as indicated by the equation:

$$d_i = \frac{a_d}{a_1 + a_2} \times 100$$

where: d_i = intermodulation distortion (in %)

a_1 = amplitude of input signal f_1

a_2 = amplitude of input signal f_2

a_d = amplitude of difference frequency signal ($f_2 - f_1$).

Note: See also Terman & Pettit "Electronic Measurements" 2nd ed., page 333, McGraw-Hill Book Company Inc., New York, 1952.

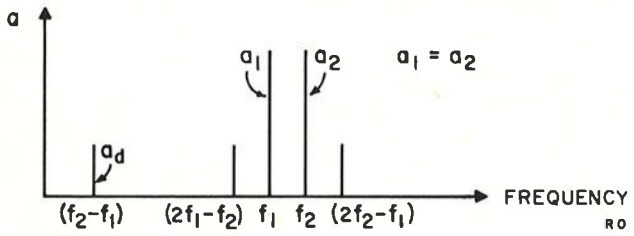


Figure 3-10. Intermodulation Frequency Spectrum (CCIF)

3-49. SIGNAL SOURCE AND TUNED VOLTMETER.

3-50. Signal source and tuned voltmeter are used as a linearly-tuned signal source for measurements on four-terminal networks to measure frequency response of filters, as a linearly swept signal source, etc.

3-51. FREQUENCY RESPONSE MEASUREMENTS. Since the Wave Analyzer provides a constant amplitude output signal of 20 cps to 50 kc in BFO operation, a system can be set up to measure conveniently the frequency response of filters. Figure 3-11 shows an arrangement to measure the filter frequency response.

3-52. Frequency response measurement can be made automatically (see figure 3-7).

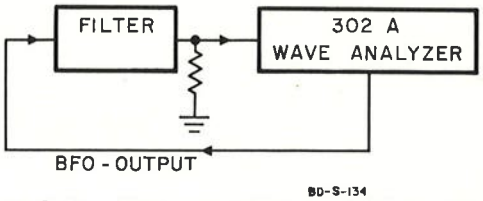


Figure 3-11. Frequency Response Measurement

3-53. NOISE MEASUREMENT.

3-54. The narrow bandwidth (6 cps) of the tuned amplifiers would indicate that extremely low noise levels could be measured. For an equivalent noise bandwidth of 6 cps, the terminal noise voltage developed in a resistor of 0.5 megohm at room temperature is 0.25 microvolts.

3-55. Semiconductors show three types of noise: Shot noise and Johnson noise which are broadband in nature and a surface noise which has a "1/f" frequency spectrum. The "1/f" noise predominates at frequencies below 1 kc.

3-56. At the low end of the frequency range (20 cps) the combined noise level is approximately 5 microvolts (at room temperature across 100K ohms), decreasing toward high frequencies.

3-57. The linear resolution of the frequency scale of the wave analyzer allows simple noise measurement across a given band within the 20 cps to 50 kc range, useful for narrow band noise measurements on amplifiers, etc.

SECTION IV
PRINCIPLES OF OPERATION

4-1. GENERAL.

4-2. Section IV describes the electrical operation of the circuits. First, the overall operation of the instrument is described with reference to the block diagram. A detailed description of the circuit section follows. For this description, please refer to the schematic diagrams of figures 5-25 through 5-28.

4-3. BLOCK DIAGRAM.

4-4. The complete block diagram of the instrument is shown in figure 4-1. The incoming signal is first attenuated (MAX. INPUT VOLTAGE) to a level which prevents overloading the input amplifier. After the signal is amplified, a low-pass filter rejects any possible 100-kc component. Frequency conversion of the input signal to the 100-kc intermediate frequency occurs in the balanced modulator, which is driven by a 100-kc to 150-kc local oscillator. The high selectivity of the instrument is obtained by cascading two crystal-tuned IF filters. After the IF signal is filtered in the first crystal filter section, attenuation of 60 db maximum can be removed by the RANGE switch to increase the readability of the front-panel meter. Note that by removing attenuation in the IF section the amplitude relationship between a fundamental signal component and its harmonic components is not altered. The amplified IF signal is filtered in the second crystal filter and amplified further in the meter amplifier, rectified and indicated by the front panel meter. A portion of the meter amplifier output (100 kc IF signal) passes through a limiter amplifier to the afc discriminator. The dc output of the discriminator controls the local oscillator frequency, thus locking the local oscillator to the input signal frequency, maintaining the 100 kc IF frequency.

4-5. The local oscillator signal is mixed with the 100 kc IF signal in the output modulator. The lower sideband component is identical with the original input signal frequency and is available at the output jack

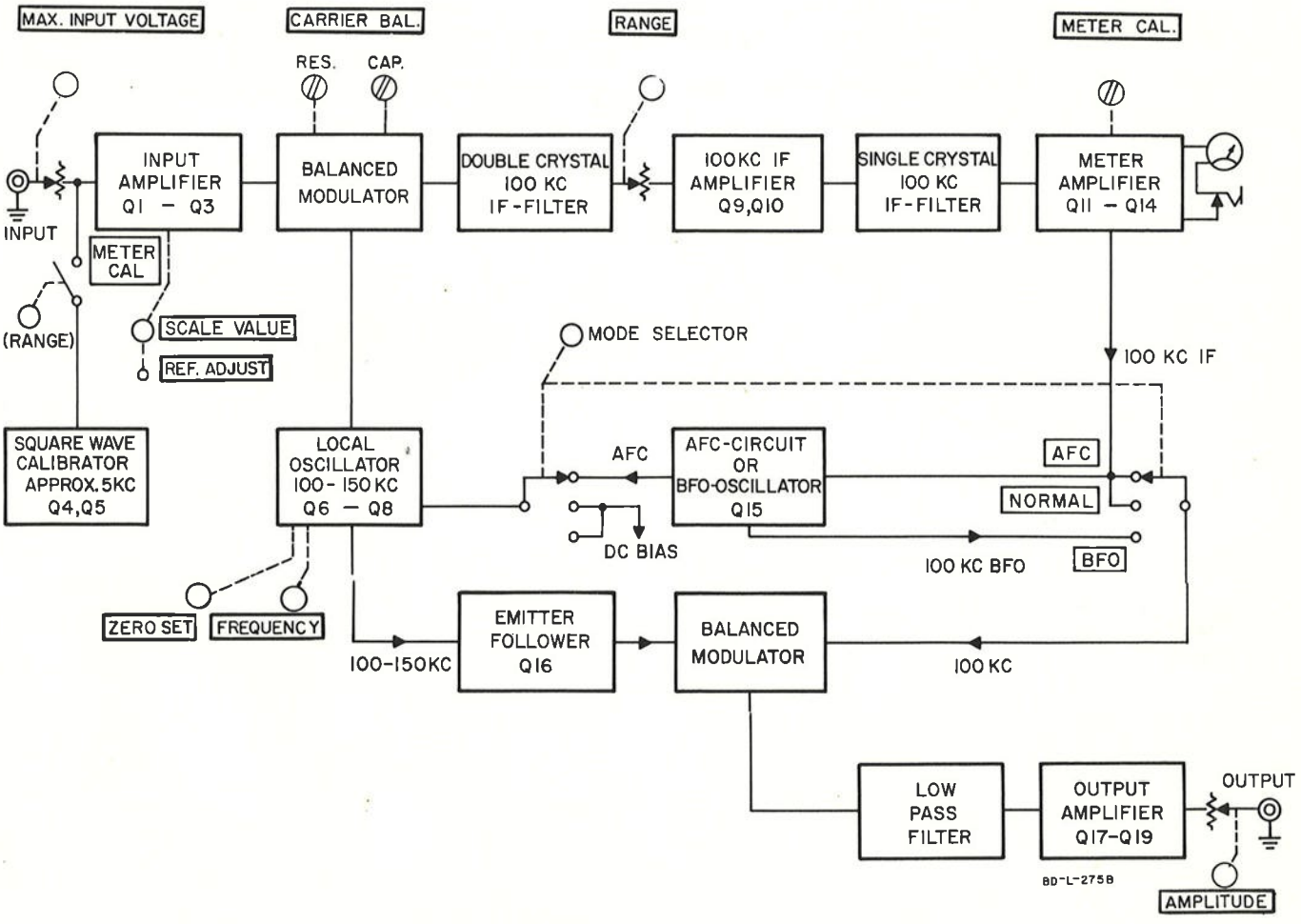


Figure 4-1. Block Diagram Model 302A

as restored frequency signal in both NORMAL and AFC operation mode.

4-6. In bfo operation the afc circuits are converted to a crystal-controlled 100-kc oscillator. The wave analyzer then becomes an oscillator combined with a highly selective voltmeter. Circuitwise the outputs of the local oscillator (100 kc to 150 kc) and of the 100 kc crystal oscillator are mixed in the output modulator, forming a constant-amplitude (1-volt minimum) bfo output signal (20 cps to 50 kc).

4-7. The calibrator supplies a square-wave signal of approximately 5 kc for meter calibration (1-volt full scale).

4-8. INPUT ATTENUATOR--AMPLIFIER.

4-9. INPUT ATTENUATOR. The input attenuator is a frequency-compensated rc divider network, which reduces the input signal level for all nine input ranges to a level which prevents overloading of the input amplifier stage. The input attenuator switch (MAX. INPUT VOLTAGE) is mechanically coupled with the dial of the RANGE switch. The highest voltage value indicated on the dial corresponds to the value selected by the MAX. INPUT VOLTAGE switch as shown in figure 4-2.

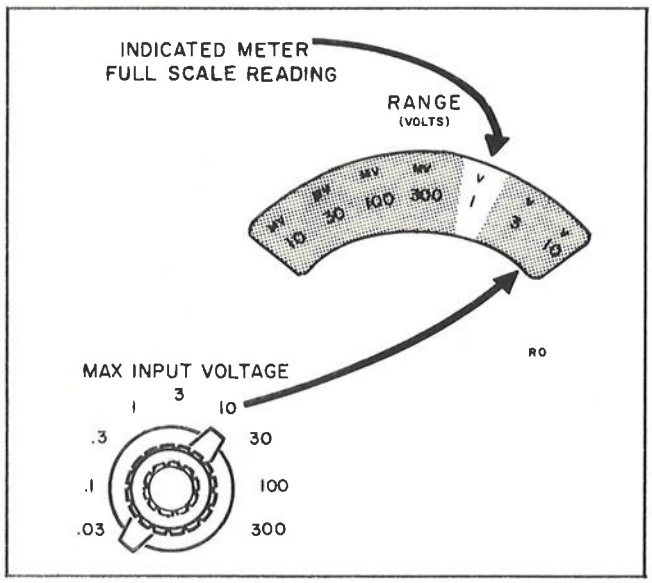


Figure 4-2. Maximum Input Voltage Range

4-10. INPUT AMPLIFIER. The input amplifier is a three-stage grounded-emitter amplifier with a closed loop gain of approximately 16 db. Diodes CR1 and CR2 provide overload protection for the input stage, Q1. If a large signal is applied to the input of Q1, the two back-biased diodes conduct, thus limiting the amplitude of the incoming signal. A large amount of negative voltage feedback is applied through C17 to the emitter of Q1 for stabilization. The SCALE VALUE selector switch controls the amount of bypassed resistance and hence the gain of the amplifier. In the ABSOLUTE position, the gain of the amplifier is constant; in the RELATIVE position, amplifier gain is variable.

4-11. 50-KC LOW-PASS FILTER. The 50-kc low-pass filter following the input amplifier is used primarily to prevent any 100-kc component of the input signal reaching the 100 kc IF filter through the modulator.

4-12. BALANCED MODULATOR.

4-13. The modulator converts the incoming signal (20 cps to 50 kc) to a 100-kc IF signal by using a local oscillator tunable from 100 kc to 150 kc. The balanced modulator, shown in figure 4-3, has a wide dynamic range, provided that the local oscillator voltage is considerably larger than the incoming signal.

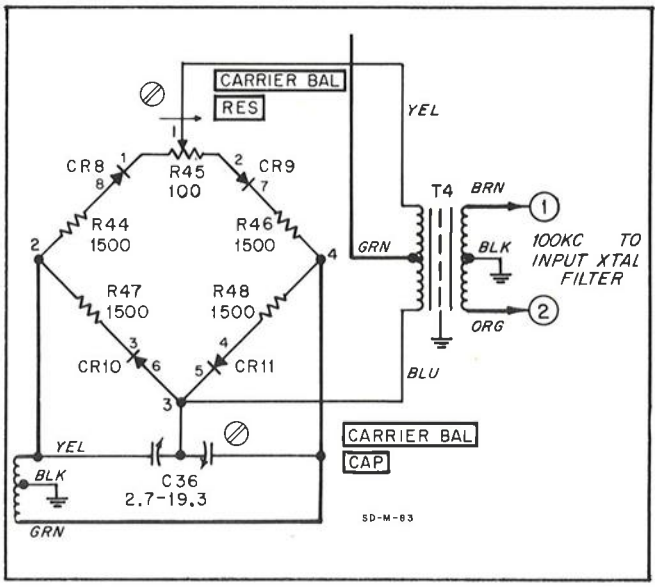


Figure 4-3. Partial Schematic of the Balanced Modulator

4-14. In the balanced modulator, diodes CR8 through CR11 are connected to form a bridge. Opposite points 2 and 4 of the bridge are fed by the local oscillator. The signal from the input is applied to the center tap of the IF transformer feeding points 1 and 3 of the bridge.

4-15. The large local oscillator signal drives two adjacent arms of the bridge alternately into conduction, providing a ground return path each time for the modulating (input) signal. As a result a voltage is induced in the secondary winding of T4 which is proportional to the modulating signal, with its polarity changed at the rate of the local oscillator frequency. This is an amplitude-modulated signal with suppressed carrier, since the modulator bridge is balanced for the local oscillator signal (carrier). From the two modulation sidebands, the lower component becomes the 100-kc IF signal. Thus for a 50-kc signal, the local oscillator is tuned to 150 kc, producing two sidebands of 100 kc and 200 kc, with the 150-kc carrier suppressed.

4-16. Balancing the modulator bridge is achieved by adjusting R45 (RES) and C36 (CAP) of CARRIER BAL. The resistors in series with the diodes virtually eliminate bridge unbalance caused by different forward resistance of the diodes.

4-17. LOCAL OSCILLATOR.

4-18. The local oscillator generates a 100- to 150-kc signal. An agc system controls the oscillator amplitude, and an afc system locks the oscillator to the frequency of the incoming signal when the instrument is operated in afc mode.

4-19. OSCILLATOR CIRCUIT.

4-20. For the following description of the oscillator circuit refer to the partial schematic of figure 4-4. Oscillator stage Q6 has its frequency-determining series-resonant circuit in its base circuit, and forms a bridge with the diodes of the agc control.

4-21. At oscillation the bridge is slightly unbalanced. Transformer T2 provides positive feedback to the bridge from the collector of Q6. Four elements control the local oscillator frequency. Inductor L7 sets the 100 kc when calibrating the instrument (ZERO SET control), and L6 is internally adjusted for the correct tuning range of L7. Capacitor C39 is the main frequency tuning control, and finally transformer T1 introduces an additional small capacitance change into the series-resonant circuit for the afc action.

4-22. AFC OPERATION.

4-23. The afc output voltage of the discriminator varies the back bias of diodes CR4 and CR5. If a diode is back biased, the junction region is depleted of majority carriers and the carrier separation acts like separated charges of a capacitor. Thus, by changing the back bias, a small capacitance change can be obtained. Transformer T1 couples the diode capacitance change into the series-resonant circuit of the oscillator. The operating point of the diodes is set with R131 (AFC BIAS). Increasing the back bias reduces the effective diode capacitance, which tends to raise the oscillator frequency. For the detailed description of afc operation refer to paragraph 4-40, AFC Discriminator.

4-24. AGC OPERATION.

4-25. The common emitter current of Q7 and Q8 is proportional to the amplitude of the local oscillator signal. A fraction of this current is passed through diodes CR6 and CR7, changing the forward bias and thus the ac impedance of the diodes.

4-26. Since the two diodes form one arm of the oscillator bridge, an impedance change will affect the

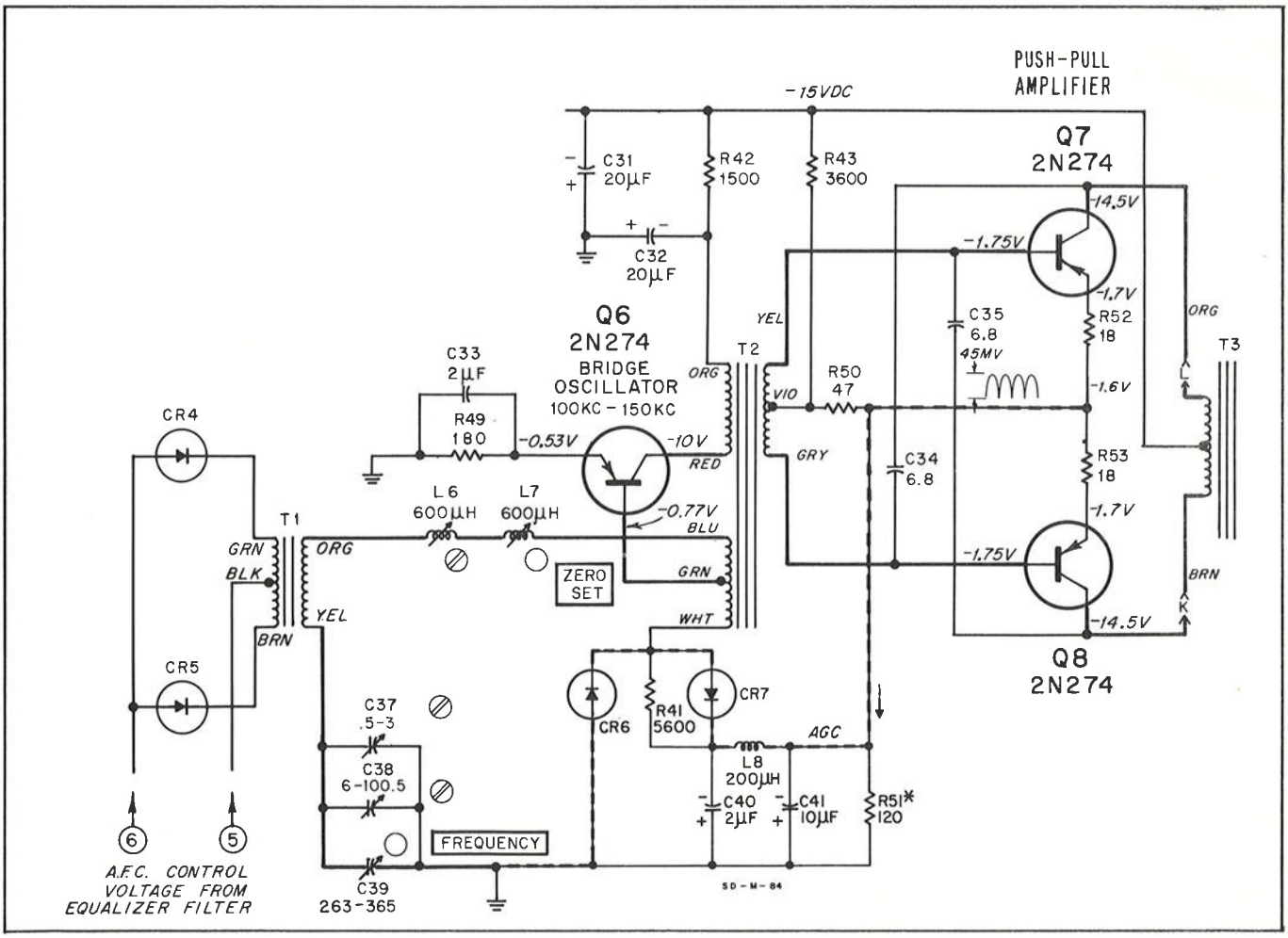


Figure 4-4. Local Oscillator

balance of the bridge. An increase of the oscillator amplitude causes larger emitter current in Q7 and Q8, and higher forward bias of CR6 and CR7. Therefore the diode impedance is reduced tending to balance the oscillator bridge, which reduces the oscillator amplitude. Padding resistor R51 determines the oscillator amplitude, since it shunts a fraction of the agc control circuit.

4-27. 100-KC CRYSTAL FILTER.

4-28. The narrow bandpass filter characteristics are obtained by cascading two crystal tuned filter sections, which are complementary for the desired frequency response. Both filter sections are of the symmetrical lattice type, whose simplified circuit is shown in figure 4-5.

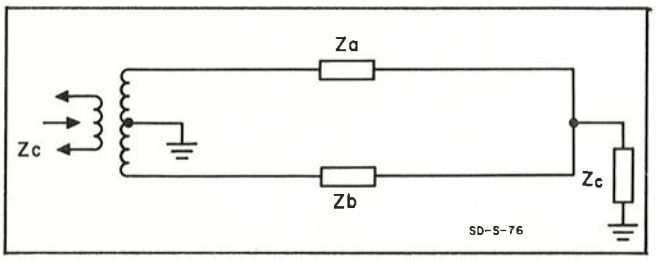


Figure 4-5. Symmetrical Lattice Type Filter

4-29. The typical frequency response of the crystals used in both filter sections is shown in figure 4-6. Note that the crystal response is capacitive for low frequencies, then passes series resonance and the closely adjacent parallel resonance. For higher frequencies the crystal acts again like a capacity. The series-resonance frequency can be slightly shifted by an external capacitor.

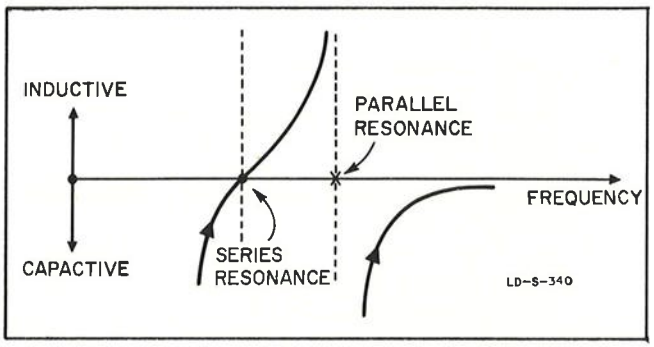


Figure 4-6. Frequency Response of Crystal

4-30. Consider now the complete filter as shown in figure 4-7. The IF signal from the modulator output passes the double crystal filter, which has a double peak response. Since any strong adjacent signal component (fundamental, when measuring harmonics) is rejected, the signal level can now be raised without overloading the IF amplifier. From the IF amplifier output, the IF signal passes the second filter section, containing one tuned crystal only which complements the frequency response of the first filter section.

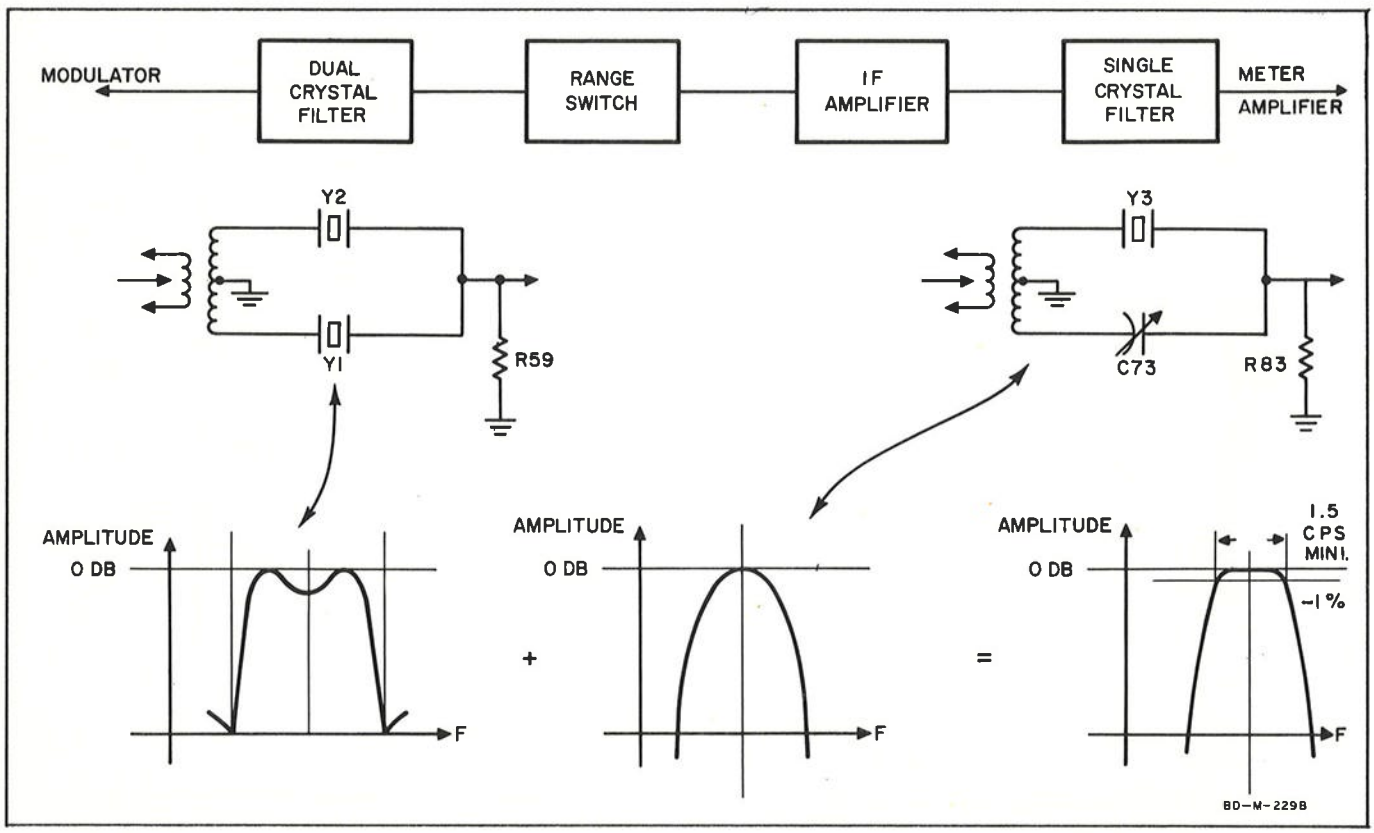


Figure 4-7. Complete 100 kc Crystal Filter

4-31. The correct frequency response of any band-pass filter depends on its proper, resistive termination. The two crystal filter sections are terminated at both input and output by tuned circuits which are tuned to become resistive and terminate the filter properly at 100 kc.

4-32. The two tuned tank circuits following the first crystal filter reject spurious response frequencies at 228 kc and 381 kc respectively. Resistive termination of the filter is obtained by tuning the two tank circuits to series resonance at 100 kc.

4-33. RANGE SWITCH, 100 KC IF AMPLIFIER.

4-34. The RANGE switch raises the input signal level to the IF amplifier by removing attenuation in 10 db steps from 60 db maximum. Figure 4-8 illustrates how the readability of the panel meter is increased by using the RANGE switch. Note that the position of the MAX. INPUT VOLTAGE remains fixed, thus maintaining the proper amplitude relationship between the fundamental component and the higher order component of a signal.

4-35. The two-stage IF amplifier has approximately 42 db gain, with negative feedback applied from the tuned output through C63 to emitter of Q9.

4-36. METER AMPLIFIER, RECTIFIER.

4-37. Refer to the circuit diagram of figure 5-27 (IF/Meter Amplifier) for the description of the four-stage meter amplifier.

4-38. All four transistor stages are of the grounded emitter type. Negative feedback is applied through C76 from the output of Q12 to the emitter Q11 to stabilize the first two stages. A fraction of the ac-return signal of the rectifier bridge is fed to the emitter of Q13 as negative feedback, stabilizing stages Q13 and Q14 and the rectifier circuit. The positive feedback loop serves to increase the output impedance of Q14. R92 (Meter Cal.) adjusts the gain of the meter amplifier when calibrating the instrument.

4-39. The amplified IF signal is fed from the collector of Q14 to a single-ended, full-wave rectifier bridge. In series with the meter is the phone-jack recorder output. Both meter and recorder jack are decoupled by bifilar-wound chokes (L13AB) from the rectifier circuit. The ac signal from the bridge is returned to ground through T6, R109 and R110. Diodes CR14 and CR15 attenuate any ac signal introduced through transformer T6 when the instrument is operating on BFO or on NORMAL. Transformer T6 couples IF signal into the afc circuit.

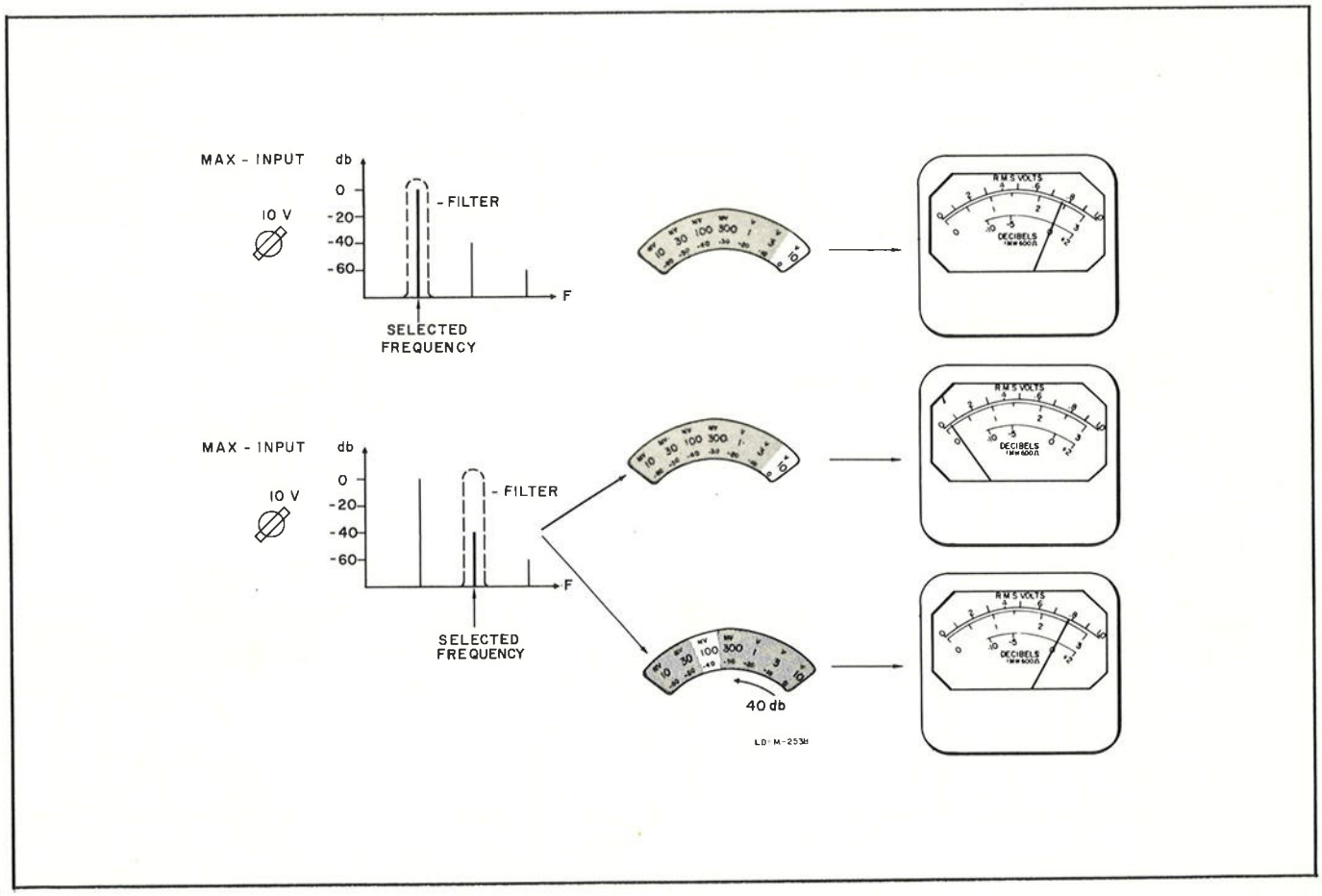


Figure 4-8. Range Selection

4-40. AFC DISCRIMINATOR.

4-41. DISCRIMINATOR CIRCUIT.

4-42. The afc discriminator provides a dc signal whose amplitude changes as the frequency of the IF signal increases. When the IF signal frequency rises above the filter center frequency, the polarity of the discriminator changes as shown in figure 4-9.

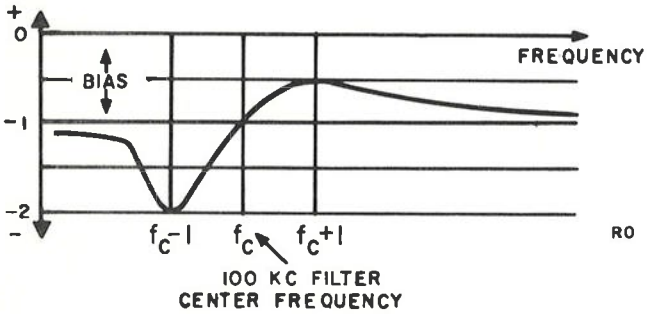


Figure 4-9. Discriminator Output

4-43. Consider the simplified discriminator circuit of figure 4-10. The IF signal coupled into the discriminator bridge is divided into two ac signals according to the impedance ratio of Y4 and C93. The impedance of crystal Y4 changes with frequency as shown in figure 4-6. The output is the sum of the two rectified signals across CR17 and CR18. In other words, if the two impedances (Y4 and C93) are equal, the resulting dc output of the discriminator is zero.

4-44. DISCRIMINATOR FREQUENCY RESPONSE.

4-45. Refer to figures 4-10 and 5-28. At low frequencies both discriminator branches (Y4 and C93) are capacitive, having approximately the same capacitance. The two rectified signals across CR17 and CR18 are equal, thus the discriminator output is zero. At the series-resonance frequency of Y4, the crystal impedance approaches zero and the IF signal appears essentially across C93 and is rectified in CR17. The discriminator output has a negative peak. At the parallel-resonance frequency of crystal Y4 the crystal

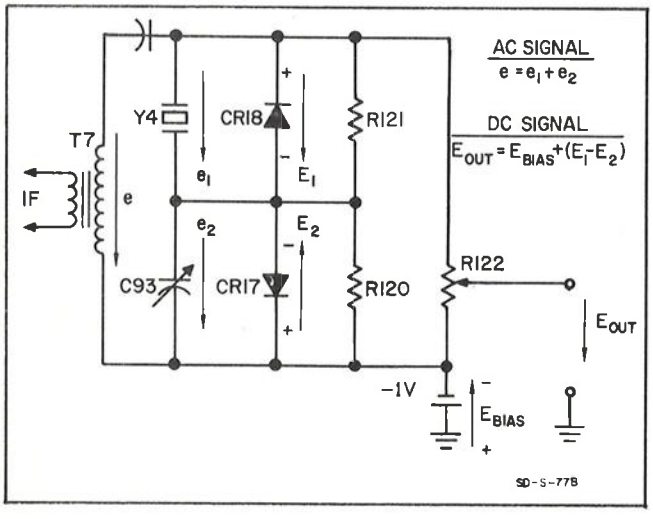


Figure 4-10. Simplified Discriminator Circuit

impedance is large compared to the impedance of C93, hence the IF signal appears essentially across Y4; it is rectified by CR18 and the discriminator output has a positive peak. At high frequencies, both discriminator branches become capacitive again resulting in zero output of the discriminator. Between the two resonance frequencies of the crystal corresponding to the negative and positive peaks of the discriminator output, there is one frequency, where crystal Y4 and capacitor C93 are in series resonance. The impedance across Y4 and C93 approaches zero, and the discriminator output will be zero.

4-46. AUTOMATIC FREQUENCY CONTROL (AFC).

4-47. The afc system of the wave analyzer can be considered as a negative feedback system, where the discriminator output corrects the local oscillator frequency for minimum IF frequency error if the input signal frequency drifts. In other words, if the input frequency starts to increase, the IF frequency will decrease so long as the local oscillator frequency remains fixed. However, the afc discriminator delivers immediately a negative-going signal, which is applied to the back biased diodes of the local oscillator circuit. Since a negative discriminator signal causes the local oscillator frequency to rise, the IF frequency will also rise and stabilize at a fixed value. The IF frequency error (within ±1 cps) is proportional to the frequency drift of the input signal frequency.

4-48. The diodes controlling the local oscillator frequency are back biased (see also paragraph 4-22). The capacitance variation determines the change of the local oscillator frequency, the afc gain adjustment controls the discriminator output amplitude for a maximum frequency hold-in range of approximately ±100 cps.

Note

The dynamic hold-in frequency of the afc system is not identical with the low drift hold-in frequency due to the limited rise time of the tuned filters and the equalizer network. Thus, although the instrument is capable of locking its local oscillator to a slow frequency drift of the incoming signal of at least ±100 cps, the dynamic hold-in range is approximately ±1 cps.

4-49. BEAT FREQUENCY OSCILLATOR.

4-50. With MODE SELECTOR in the BFO position, the afc discriminator circuits are connected to form a 100-kc crystal-controlled oscillator. A simplified diagram of the bfo oscillator is shown in figure 4-11.

4-51. Oscillation occurs for a frequency where crystal Y4 is in series resonance. The series resonance frequency is set with C90 after adjusting the afc discriminator. The bfo oscillator signal is fed through a 100-kc series-resonant circuit from the base of Q15 to bfo output control R116 and the output circuits. CR17 limits the amplitude of oscillations to approximately 14 volts peak-to-peak maximum.

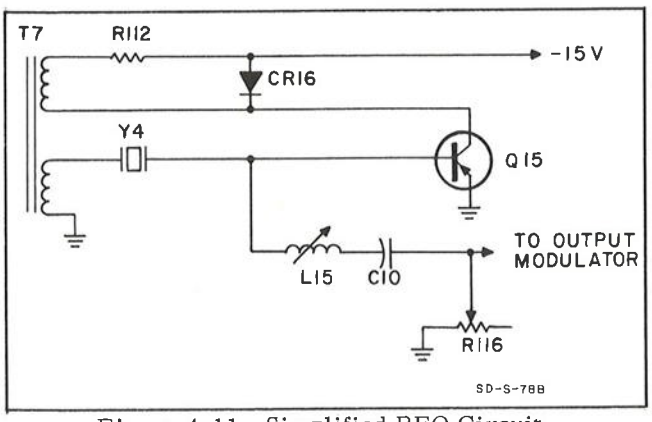


Figure 4-11. Simplified BFO Circuit

4-52. In NORMAL operation the bias voltage for diodes CR4 and CR5 is adjusted with R129 (Norm. Bias Adj.).

4-53. OUTPUT MODULATOR AND AMPLIFIER.

4-54. OUTPUT MODULATOR. The output modulator and the associated amplifiers provide an output signal, whose frequency and amplitude depend on the operation mode of the wave analyzer. Refer to figure 4-12 showing the simplified circuit.

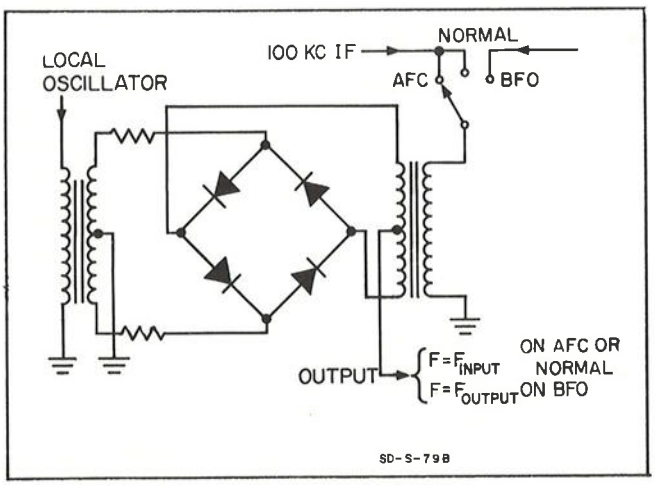


Figure 4-12. Output Modulator Section

4-55. In AFC and NORMAL modes, the 100 kc IF signal is mixed with the local oscillator signal to produce an output signal at the frequency of the original input signal.

4-56. In the BFO mode a 100-kc signal of the crystal controlled bfo is mixed with the local oscillator signal creating a beat frequency signal whose frequency is indicated by the FREQUENCY dial of the instrument.

4-57. The local oscillator signal passes through emitter follower stage Q16 before driving the output modulator. The operation principle of a balanced modulator is described in paragraph 4-12. From the output of the modulator the output signal passes a 50-kc low-pass filter and is amplified in a three-stage output amplifier, Q17 through Q19.

4-58. OUTPUT AMPLIFIER. The output amplifier is a three-stage, dc-coupled amplifier as shown in figure 5-28. To maintain the level and polarity of the dc biases stage Q18 is an NPN type. DC feedback is applied across all three stages from the emitter of Q19 to the emitter of Q17 through R144. The amplitude of the output signal is controlled by R149 in the collector circuit of Q19.

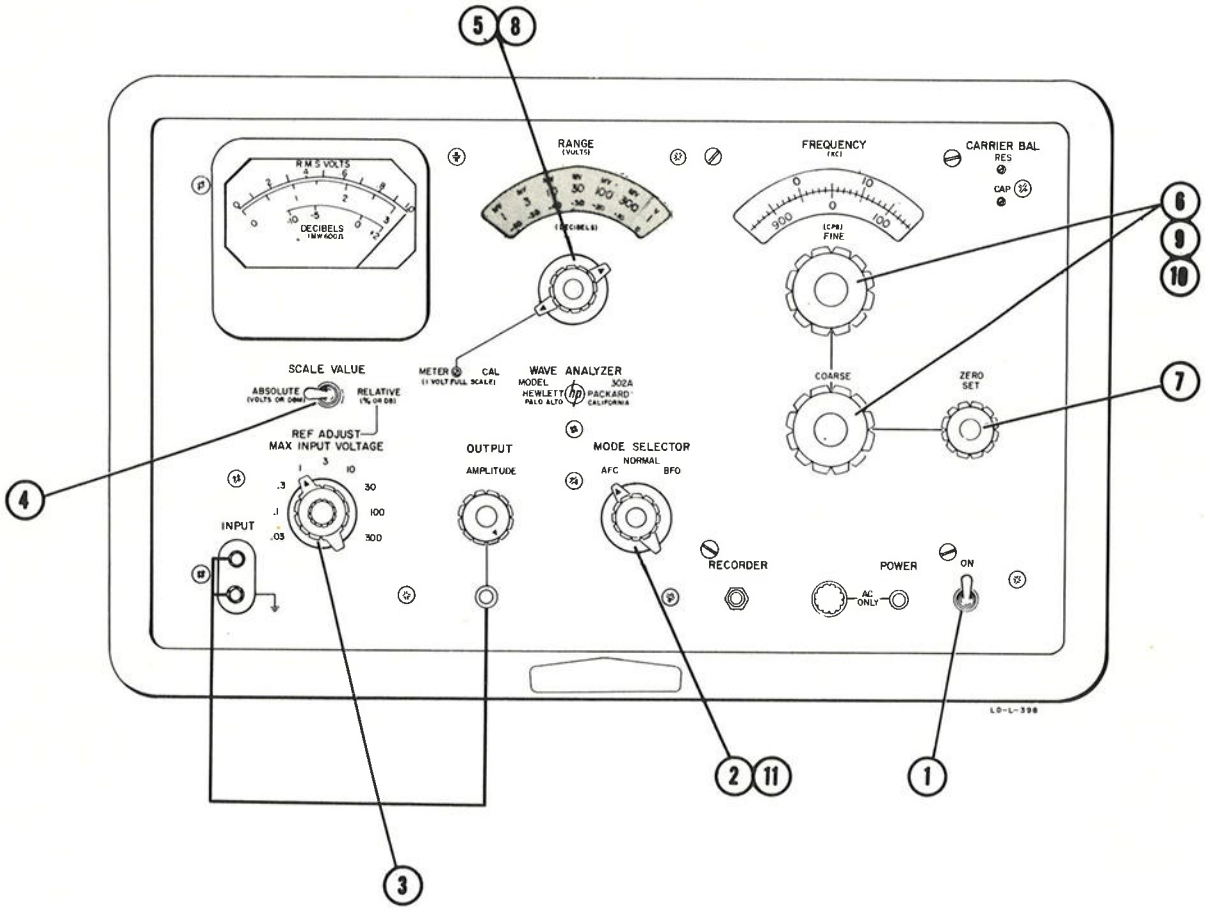
4-59. CALIBRATOR.

4-60. Stages Q4 and Q5 form a free-running multivibrator oscillating at approximately 5 kc. Breakdown diode CR3 limits the negative amplitude of the square wave.

4-61. REGULATED POWER SUPPLY.

4-62. The regulated power supply is of the conventional type, using grounded emitter stage Q21 to drive series regulator Q20. Figure 5-25, Power Supply, shows the complete circuit diagram of the regulated power supply and the supply circuits. Breakdown diode CR27 provides the voltage reference level.

4-63. The power input circuits are conventional. The indicator light operates only on ac. Selector switch S5 has to be set separately when changing from ac to dc operation. Diode CR26 protects the instrument against reversal of battery polarity.



LOCAL OSCILLATOR

1. Turn on instrument.
2. Set MODE SELECTOR to NORMAL.
3. Set MAX. INPUT VOLTAGE switch to 1.
4. Set SCALE VALUE switch to ABSOLUTE.
5. Set RANGE switch to 10 MV (-40 DB).
6. Set FREQUENCY dial to 0.0 KC.
7. Rotate ZERO SET control for a peak reading on panel meter.

   If a meter reading below -40 db of the MAX. INPUT VOLTAGE setting is obtained, the local oscillator is oscillating at 100 kc, and the modulator is properly balanced.

AFC OPERATION

8. Set RANGE switch to METER CAL (extreme clockwise position).
9. Tune FREQUENCY dial for frequency of calibration oscillator (approximately 4-6 kc) for maximum reading.

   If the maximum meter reading is approximately 1.0 volt, the amplifier sections of the instrument are operating normally.

10. Reduce meter reading to 0.1 volt by detuning the 302A with the FREQUENCY dial control.
11. Switch MODE SELECTOR to AFC and observe the effect of the afc operation on the meter.

    If the meter reading increases gradually to the original maximum reading before detuning, the afc circuits are operating.

Figure 5-1. Front-Panel Performance Check

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains information on the maintenance and repair of the Model 302A Wave Analyzer. Before making any adjustments or replacements read paragraphs 5-3 through 5-6.

5-3. GENERAL MAINTENANCE INFORMATION.

5-4. The Model 302A Wave Analyzer is a fully transistorized instrument and under normal operating conditions requires little or no maintenance throughout the life of the instrument. Do not troubleshoot this instrument without carefully studying the troubleshooting information given in this manual. Changing an adjustment setting accidentally might involve considerable alignment time.

CAUTION

The instrument incorporates sharply-tuned crystal filters whose adjustments should not be touched. Even a slight change of any one of the filter adjustment capacitors affects the selectivity characteristics and thus the performance of the instrument. The selectivity check given in figure 5-5 tests all sections of the filter systematically, including the overall selectivity of the instrument.

5-5. TRANSISTOR CIRCUITS. Turn off instrument when replacing a transistor (or any other circuit component). If a transistor needs to be replaced refer to paragraph 5-19.

5-6. MECHANICAL ASSEMBLIES. The Model 302A contains mechanical assemblies which are lubricated for the lifetime of the instrument and under normal operation do not require maintenance.

CAUTION

Do not drive the tuning capacitor against the mechanical stops at either end of its rotation by fly-wheeling the drive with the COARSE control.

5-7. TEST EQUIPMENT.

5-8. The equipment recommended for testing and repairing the Model 302A is listed in table 5-1, Maintenance Test Equipment.

5-9. CABINET REMOVAL.

5-10. The cabinet of the Model 302A is removed as follows:

a. Remove five "Phillips" screws (one round-head and four sheet-metal screws) on the back cover.

b. Provide clearance for the binding posts, and place instrument on its rear cover.

c. Unscrew the two screws holding the panel to the cabinet bezel.

d. Remove cabinet by lifting it vertically.

Table 5-1. Maintenance Test Equipment

Instrument Type	Required Characteristics	Use	Instrument Recommended
DC Voltmeter Ohmmeter	Voltage Range: 1 volt to 300 volts Input Impedance: at least 100 megohms Resistance Range: from less than 100 ohms to at least 100 megohms	Voltage and resistance measurements	hp Model 410B, 412A
AC Voltmeter	Voltage Range: 1 mv to 10 v rms Input Impedance: at least 1 megohm shunted by 50 pf maximum	Voltage measurements	hp Model 400D, 400H
Oscillator	Output Voltage: 10 volts Output Impedance: max. 1000 ohms Frequency Range: 5 cps to 100 kc min.	AC signal source for troubleshooting	hp Model 200AB, 200CD, 200J or 202C
Oscilloscope	Pass Band: dc to at least 200 kc Input Impedance: 1 megohm min. Sensitivity: 0.01 volt per division	Observe waveforms for troubleshooting and adjustments	hp Model 120A, 130B, 122A (dual channel)
Counter	Maximum counting rate at least 100 kc	Frequency accuracy check	hp Model 522B, 523CD, or 524CD
Voltmeter Calibrator	Output: 30 mv to 300 volts in 10 db steps at 400 cps Accuracy: ±1%	Voltage accuracy check attenuator adjustment	hp Model 738A

5-11. CONVERSION FOR 230-VOLT OPERATION.

5-12. Remove two jumper wires of tie point strip (power supply section) and use one jumper wire to connect the black/yellow lead to the black/green lead as shown in figure 5-2. No fuse change is required when changing from 115 volt to 230 volt operation.

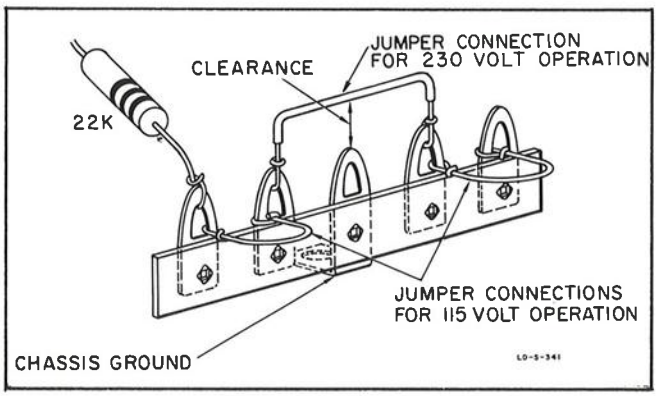


Figure 5-2. 230-Volt Operation

5-13. FRONT-PANEL PERFORMANCE CHECK.

5-14. Figure 5-1 describes a performance check which can be performed with the instrument in its cabinet and without additional equipment. These tests will establish that the instrument is operating normally. The tests will not check the accuracy of the instrument. Refer to paragraph 5-15 for the accuracy check.

5-15. ACCURACY CHECK.

5-16. To determine the accuracy of the Model 302A refer to the following checks:

Figure 5-3. Voltage Accuracy Check
Figure 5-4. Frequency Accuracy Check
Figure 5-5. Selectivity Check
Figure 5-6. AFC Discriminator Check
Figure 5-7. BFO Output Check

5-17. The test equipment required for these checks is listed in table 5-1.

5-18. Further checks that verify the specifications of the Model 302A are listed in table 5-3 and are:

Ref. L Input Attenuator
Ref. M IF Attenuator
Ref. O Meter Tracking
Ref. P Distortion

5-19. ADJUSTMENT AFTER COMPONENT REPLACEMENT.

5-20. After replacing a transistor, the Model 302A will most probably operate within specifications. Table 5-2 lists a number of checks which need to be done after transistor replacement. Do not make any adjustment in the instrument as long as a check proves to be within specifications.

5-21. MAINTENANCE ADJUSTMENT PROCEDURE.

5-22. The maintenance adjustment procedure provides a complete series of checks, typical voltages and adjustments covering systematically the circuits of the Model 302A. This procedure is recommended when troubleshooting the instrument. After a trouble has been localized and the cause removed, the information in the maintenance adjustment procedure enables the restoration of operation within specifications.

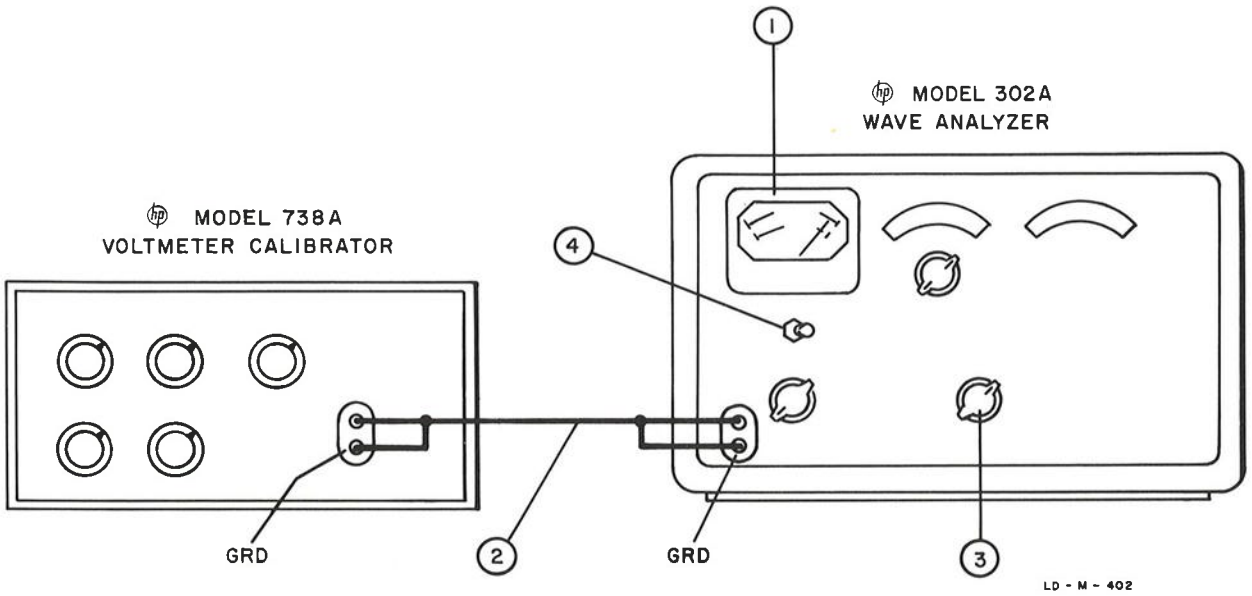
5-23. Table 5-3 shows the maintenance procedure, with each measuring step covered by a separate reference letter. Read the columns associated with one reference letter from left to right. The column to the extreme right lists checks and components leading to a possible trouble cause. Table 5-1 lists test equipment required for these measurements. Other items of equipment may be substituted for those in the table. The accuracy of the substitute equipment should meet the requirements listed.

Note

Do not interchange the four crystals. Such an interchange will destroy the bandpass filter characteristics. If one of the four crystals is damaged, contact your Hewlett-Packard sales representative.

Table 5-2. Adjustment after Transistor Replacement

Component Replaced	Check	Reference
Q1, Q2, Q3	Input Amplifier	Table 5-3C
	Meter Calibration	Figure 3-2
Q4, Q5	Square Wave Calibration	Table 5-3B
	Meter Calibration	Figure 3-2
Q6	Frequency Accuracy	Figure 5-4
	Local Oscillator	Table 5-3F
Q7, Q8	Carrier Balance	Figure 3-2
Q9, Q10	IF Amplifier	Table 5-3E
	Selectivity Check	Figure 5-5
Q11 thru Q14	Meter Amplifier	Table 5-3D
	Selectivity Check	Figure 5-5
	Meter Tracking	Table 5-3O
Q15	BFO Crystal Oscillator	Table 5-3K
	AFC Discriminator	Table 5-3J
Q17, Q18, Q19	Output Amplifier	Table 5-3G
Q20, Q21, Q22	Regulated Power Supply	Table 5-3A



1. Calibrate instrument as shown in figure 3-2.
2. Connect instruments as shown.
3. Set MODE SELECTOR to NORMAL.
4. Set SCALE VALUE to ABSOLUTE.

PROCEDURE

The Model 302A meter reading is compared with the input signal level at all positions of the MAX. INPUT VOLTAGE switch and the RANGE switch.

Set MAX. INPUT VOLTAGE switch to 0.03 volt, RANGE switch to 30 MV and apply 0.03 volt rms from Model 738A. Tune Model 302A (approximately 400 cps) and change MODE SELECTOR to AFC. Adjust METER CAL for full scale (3.0).

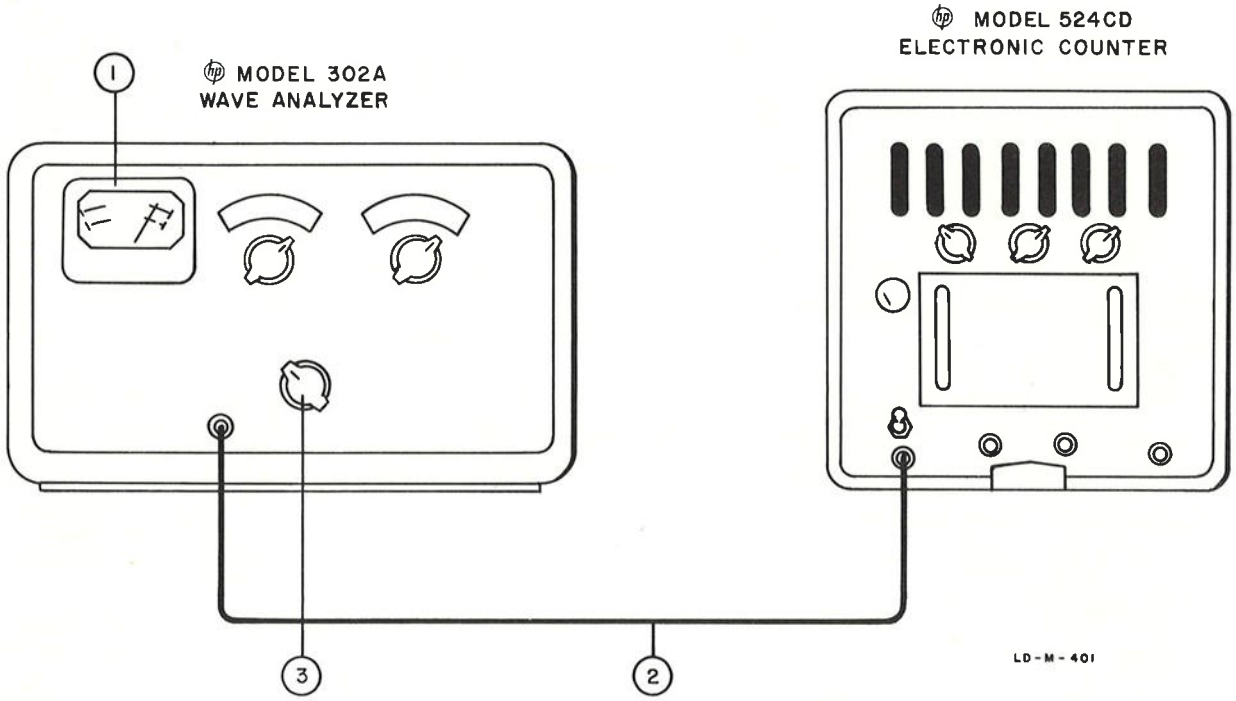
Increase input signal and MAX. INPUT VOLTAGE switch in 10 db steps (0.3V - 300V) and observe Model 302A meter reading.

Specification: Meter readings should remain within ±5% of input.

Set MAX. INPUT VOLTAGE switch to 0.3V, RANGE switch to 0.3V and apply 0.3V rms from Model 738A. Maintaining input voltage constant, rotate MAX. INPUT VOLTAGE switch clockwise in 10 db steps, while decreasing (counterclockwise) RANGE switch in 10 db steps.

Specification: Meter reading should be 3.0V (±5%) for each setting.

Figure 5-3. Voltage Accuracy Check



1. Calibrate instrument as shown in figure 3-2.
2. Connect instrument as shown.
3. Set MODE SELECTOR switch to BFO.

PROCEDURE

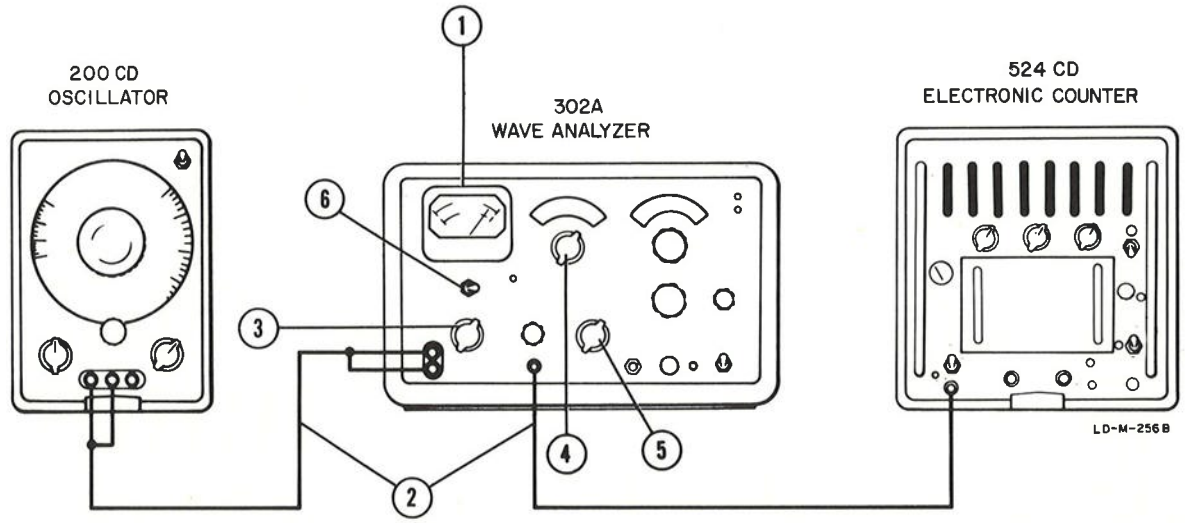
The Model 302A frequency dial reading is compared with the counter reading by setting the Model 302A FREQUENCY dial to frequencies between 20 cps and 50 kc and reading the bfo frequency on the counter.

BFO Frequency Accuracy. Set Model 302A FREQUENCY dial to 20 cps; readjust ZERO SET so counter indicates 20 cps. Note that the initial counter reading should be within 20 cps ±5 cps, indicating correct bfo crystal frequency.

Calibration Accuracy (Linearity). Check dial calibration by comparing dial setting with counter reading from 20 cps to 50 kc.

Specification: Counter reading should be within ±(1% +5 cps) of dial reading.

Figure 5-4. Frequency Accuracy Check



1. Calibrate 302A as shown in figure 3-2.
2. Connect instrument as shown.
3. Set MAX. INPUT VOLTAGE switch to 3 volts.
4. Set RANGE switch to 3 volts.
5. Set MODE SELECTOR to NORMAL.
6. Set SCALE VALUE switch to RELATIVE.

PROCEDURE

The selectivity of the 302A bandpass filter is measured by determining the filter center frequency (3 db points), the passband characteristics (-1% points), and the filter rejection characteristics (-80 db points).

A. Center Frequency. Set 200CD Oscillator to 25 cps and set 302A at 25 cps.

Adjust REF ADJUST control for 0 db meter reading at tuning peak.

Change 200CD Oscillator frequency until meter reading drops to -3 db (two frequencies). Read counter and record the two frequencies, f_a and f_b.

Specification: 3 db bandwidth should not exceed 7 cps.

Compute filter center frequency $f_c = 1/2 (f_a + f_b)$.

B. Pass Band Characteristics (-1%). Tune 200CD Oscillator to center frequency of filter (read counter).

Adjust REF ADJUST control so meter reads 1.0 volt (100%).

Increase 200CD frequency until 302A meter reading drops by one half of a scale division (1%). Read counter and record frequency (f_{11}).

Set 200CD back to tuning peak (center frequency) and decrease frequency until meter reading drops again by one half of a scale division (1%). Record counter frequency (f_{12}).

Note: Determining the -1% points is critical and requires care; repeat procedure if necessary.

Specification: Passband characteristic meets the specification if difference between the two ±1% points is greater than or equal to 1.5 cps. If difference (f_{11}-f_{12}) is less than 1.5 cps, refer to table 5-3, step H.

C. Filter Rejection Characteristics (-80 db). Set 200CD frequency to 260 cps, and set 302A to peak at 260 cps.

Adjust REF ADJUST control so meter reads 1.0 volt (used for 0 db reference).

Decrease oscillator frequency to 190 cps.

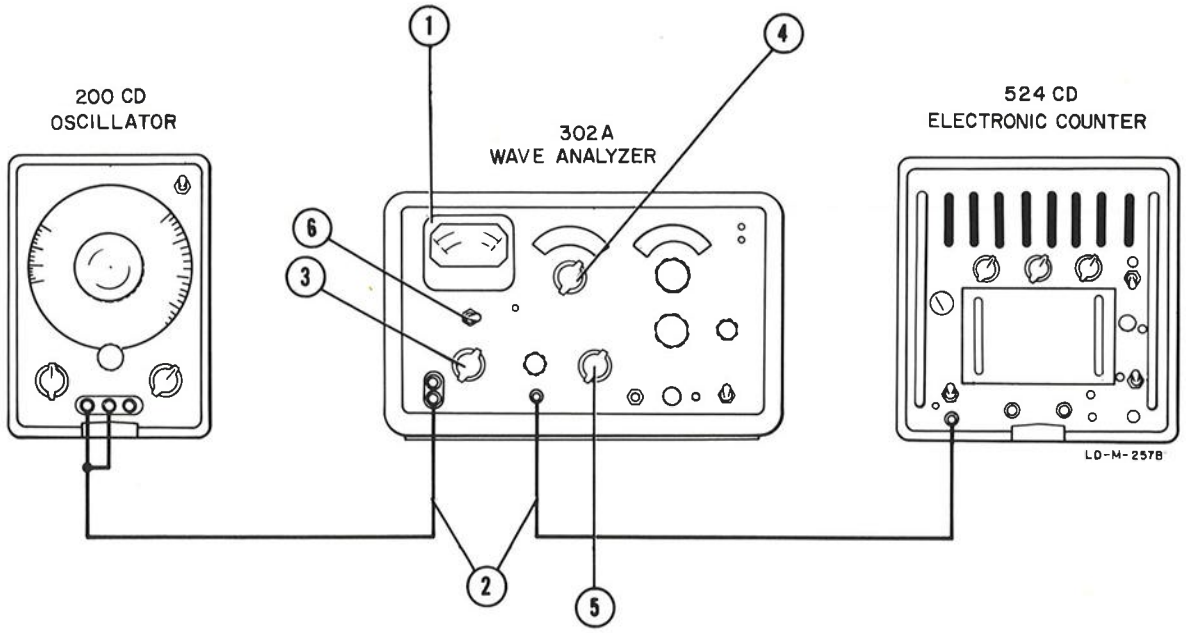
Specification: Rejection characteristics meet specifications if meter reads below 0.1 volt with RANGE switch turned fully counterclockwise (-80 db).

Note: -80 db is obtained by adding -60 db (RANGE switch) to -20 db (obtained from 10% of original meter reading).

If meter reading at f_c ±70 cps is higher than 0.1 volt (RANGE switch fully counterclockwise), refer to table 5-3, step H.

Increase oscillator frequency to 330 cps. Meter reading should again be below -80 db.

Figure 5-5. Selectivity Check



1. Calibrate 302A as shown in figure 3-2.
2. Connect instruments as shown.
3. Set MAX. INPUT VOLTAGE switch to 3 volts.
4. Set RANGE switch to 3 volts.
5. Set MODE SELECTOR to NORMAL.
6. Set SCALE VALUE switch to RELATIVE.

PROCEDURE

The correct operation of the afc discriminator circuit is checked by determining the frequency hold-in range.

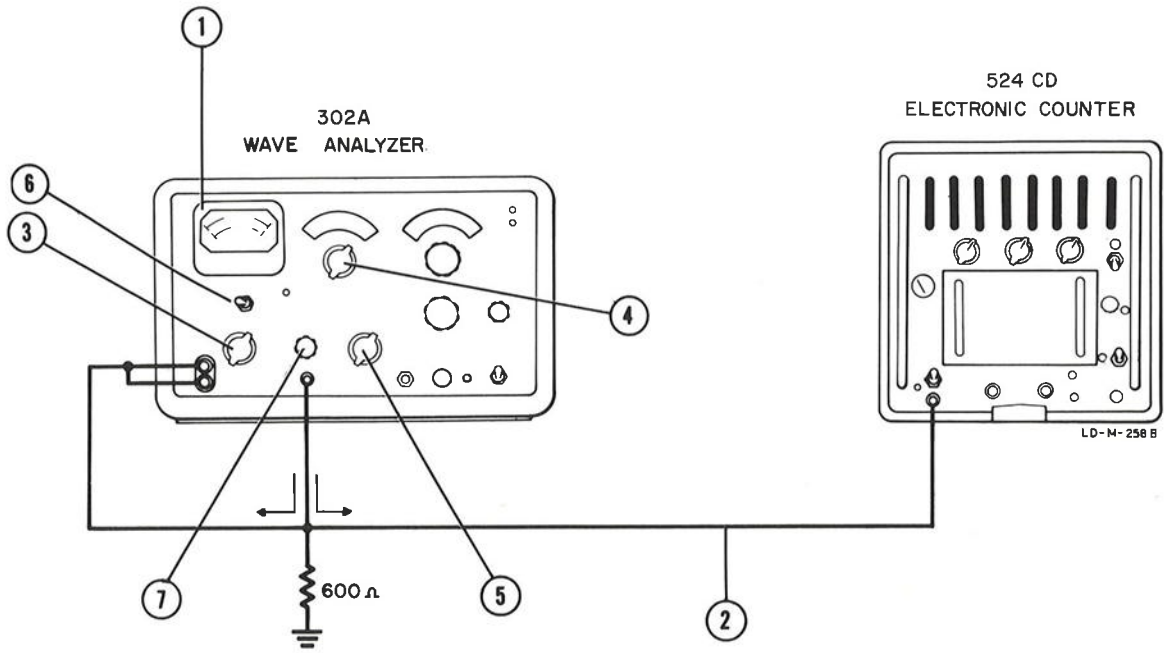
Frequency Hold-In Range. Set 200CD Oscillator to 400 cps; tune 302A to 400 cps.

Adjust REF ADJUST for 1.0 volt and switch MODE SELECTOR to AFC.

Increase oscillator frequency slowly so that afc circuit automatically retunes and tracks input signal frequency. The afc circuit will eventually lose control causing a sudden drop in the meter reading. Record the counter reading at this point. Repeat hold-in range check by decreasing frequency slowly, starting at 400 cps.

Specification: Frequency hold-in range for slow input signal frequency changes, ±100 cps minimum. If hold-in range is below ±100 cps refer to table 5-3, step J.

Figure 5-6. AFC Discriminator Check



1. Calibrate instrument as shown in figure 3-2.
2. Connect instrument as shown.
3. Set MAX. INPUT VOLTAGE switch to 1V.
4. Set RANGE switch to 1V.
5. Set MODE SELECTOR to BFO.
6. Set SCALE VALUE switch to ABSOLUTE.
7. Set output AMPLITUDE control fully clockwise.

PROCEDURE

The correct bfo operation is checked by comparing a selected Model 302A FREQUENCY dial reading with the counter reading (see also figure 5-4, Frequency Accuracy Check), and measuring the OUTPUT amplitude with the internal meter.

Frequency: Set Model 302A FREQUENCY dial to 1.000 KC and read counter.

Specification: BFO crystal frequency correct if counter reading is within 1 kc ± 15 cps (refer also to table 5-3, step K).

Amplitude: BFO OUTPUT amplitude is correct if meter reading is greater than or equal to 1.0V (refer to table 5-3, step G).

Figure 5-7. BFO Output Check

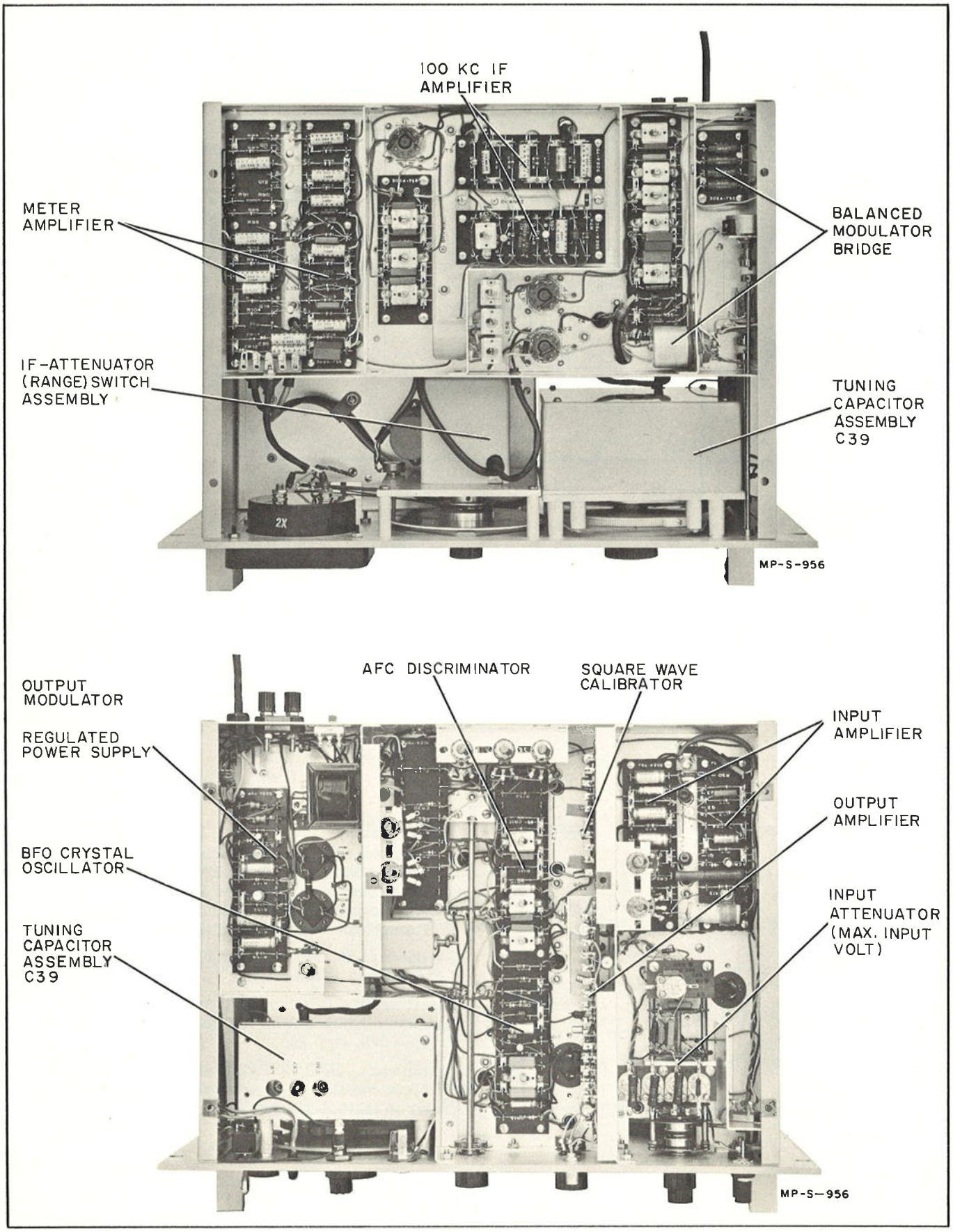


Figure 5-8. Model 302A Identification of Circuits

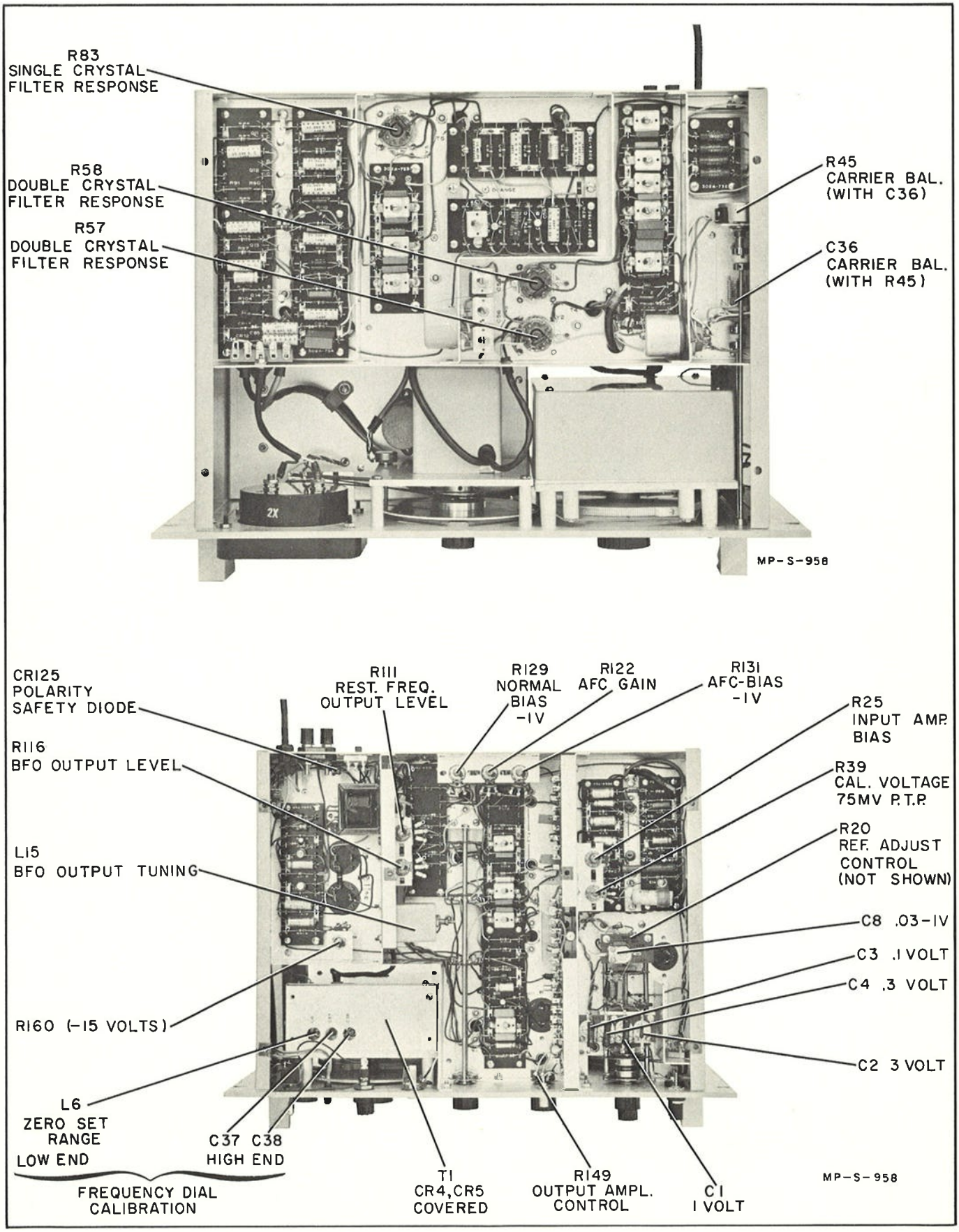


Figure 5-9. Model 302A Identification of Adjustments

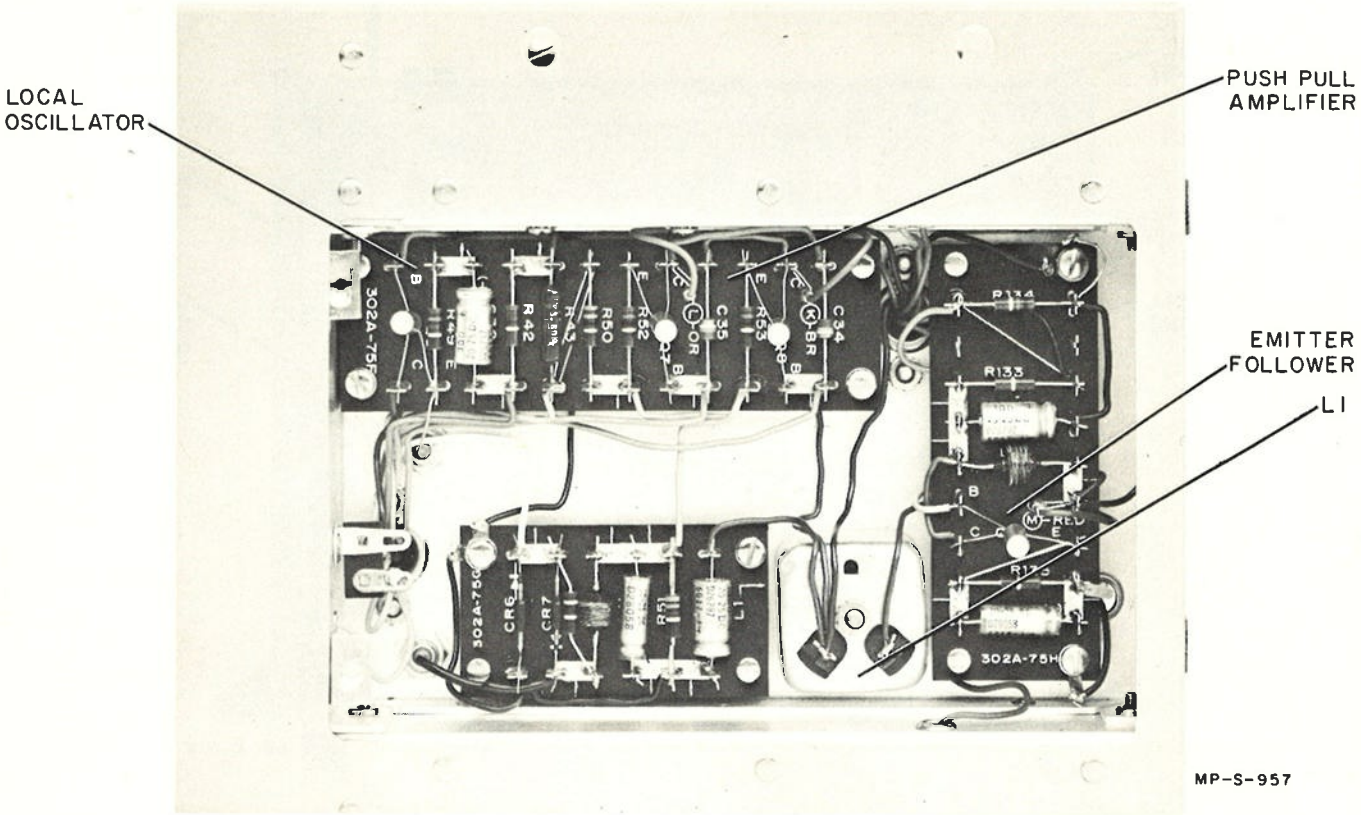


Figure 5-10. Right Side View Model 302A Identification of Circuit Sections

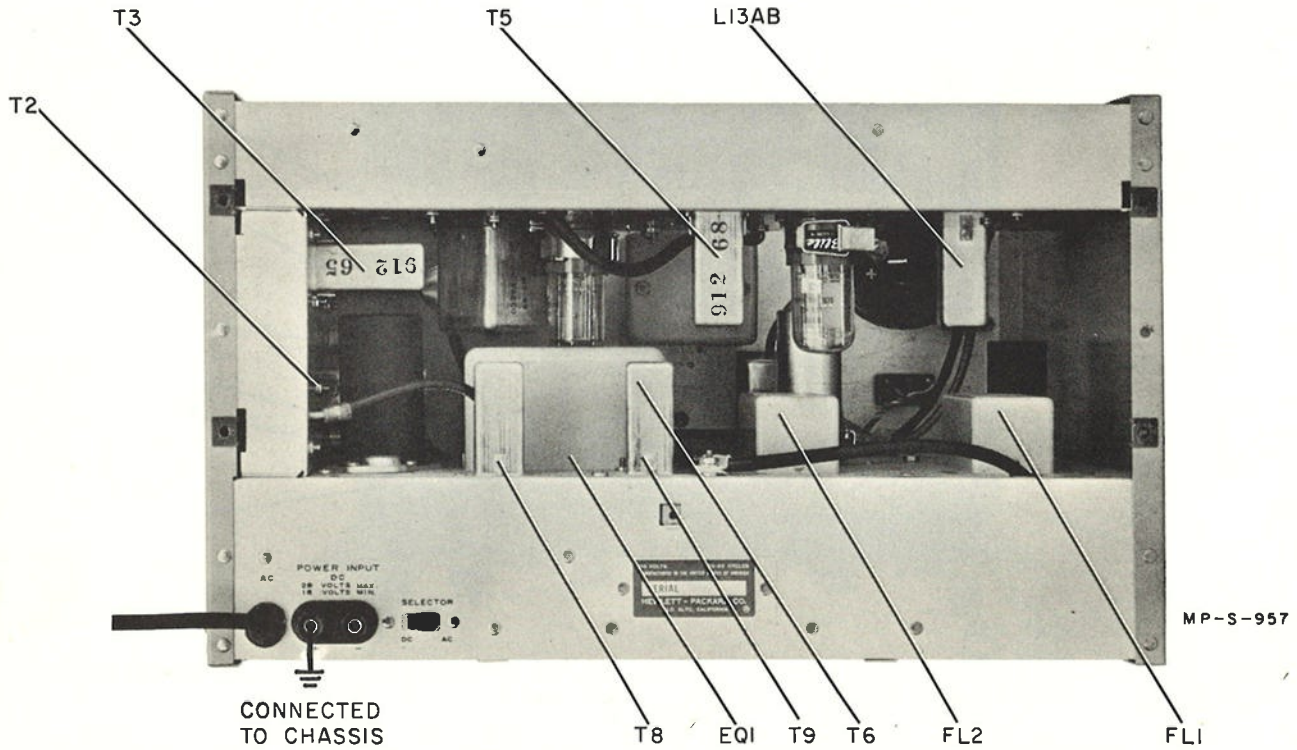


Figure 5-11. Rear View Model 302A Identification of Circuit Sections

Table 5-3. Maintenance Checks and Adjustments

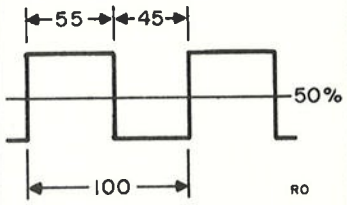
Ref	Test Equipment and Connections	Important Control Settings	Measure - Adjust	Repair - Check - Replace
A		REGULATED POWER SUPPLY		
A1	DC VOLTMETER	302A RANGE switch fully clockwise	Measure at emitter of Q20 (-15.0 ±0.2 volt). Adjust R160 for -15 volts.	Bias voltages Unfiltered dc
A2	AC VOLTMETER		Measure ripple voltage at collector of Q20 (150 μv maximum).	Diodes CR24, CR25, CR27 Transistors Q20, 21, 22
B		SQUARE-WAVE CALIBRATION		
B1	OSCILLOSCOPE	302A RANGE switch to METER CAL.	Measure at collector of Q5 6.5 volts to 7.5 volts p-p.	Bias voltages Diode CR3
B2	OSCILLOSCOPE		Measure symmetry between 45/55 and 55/45 at 50% points.	Transistors Q4, Q5 Capacitor C29/C30 
C		INPUT AMPLIFIER		
C1	VOLTMETER CALIBRATOR Feed 30 mv at 400 cps to INPUT of 302A	MAX INPUT VOLTAGE switch to 30 MV	Gain correct if signal at emitter of Q3 approximately 197 mv (600 mv p-p).	Check voltage across C17 (approximately 2 volts dc) Collector Q1, 5 mv p-p.
C2	VOLTMETER CALIBRATOR	SCALE VALUE switch to RELATIVE	Range of REF ADJUST control correct, if meter indication changes by 10 db minimum	Bias voltages; CR1, CR2 Q1, Q2, Q3
D		METER AMPLIFIER		
D1	VOLTMETER CALIBRATOR Feed 30 mv at 400 cps to INPUT of 302A	MAX INPUT VOLTAGE switch to .03 RANGE switch to 30 mv SCALE VALUE to ABSOLUTE	Gain correct if meter indicates full scale Adjust R92 METER CAL for 30 mv	Check IF gain Low gain; check bias voltages, replace transistors, starting with Q12, Q11, Q13, Q14. No meter reading: check collector of Q14, 3.5 volt p-p; check meter circuit.
D2		RANGE switch to METER CAL. Tune 302A to internal calibrator frequency (approximately 4-6 kc).	Meter reading should vary by ±2.5 db, when turning METER CAL adjustment through its range.	Check gain of meter amplifier.

Table 5-3. Maintenance Checks and Adjustments (Cont'd)

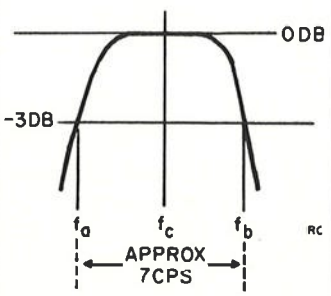
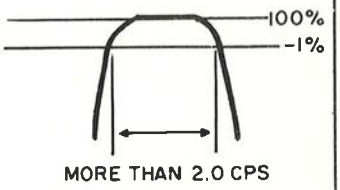
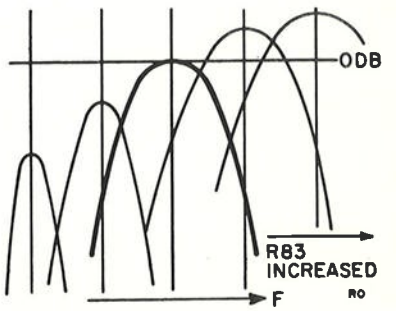
Ref	Test Equipment and Connections	Important Control Settings	Measure - Adjust	Repair - Check - Replace
E		IF AMPLIFIER		
	OSCILLATOR			
E1	Disconnect pin G and pin J. Feed 100 kc signal through 1500 ohm resistor to input of IF attenuator (pin 5 of crystal Y2)	MAX INPUT VOLTAGE switch to 1V RANGE switch to 1V	Measure input level at junction of R74 and R75 Gain of IF amplifier correct, if input level -42 db or below.	Bias voltages Q9, Q10 IF attenuator switch.
	Disconnect pin C and pin E and connect 3000 ohm resistor (±15%) between pin C (yellow lead of T5) and ground.			
	Connect ac voltmeter (400H or 400D) across 3K resistor and adjust 100 kc signal amplitude for a 0 db reading.			Remove 3K resistor Reconnect pins G, J, C, and E.
F		LOCAL OSCILLATOR		
F1	Connect meter (oscilloscope) to output of T3 (yellow lead of resistor board in balanced modulator section).	Set FREQUENCY dial of 302A to 1.0 kc	Correct local oscillator amplitude 8.0 - 8.4 volt rms (approximately 25 volts p-p). Observe waveshape	Adjust pad R51 for correct amplitude Check Q7, Q8
F2		Vary FREQUENCY dial from 20 cps to 50 kc	Correct amplitude variation less than 2 db; measure at 1 kc, 20 kc, and 50 kc.	Check CR6, CR7
F3	Connect meter (oscilloscope) to emitter of Q16.		Correct amplitude 1.0 to 1.5 volts rms (2.8 to 4 volts p-p).	Check T3
G		OUTPUT AMPLIFIER		
G1	Feed 1 volt rms to INPUT	MAX INPUT VOLTAGE switch to 1 volt. MODE SELECTOR to AFC. OUTPUT AMPLITUDE fully clockwise.	Correct OUTPUT AMPLITUDE approximately 2.5 volts rms (approximately 7 volts p-p).	Signal at centerarm of R111 (Rest. Freq. Output Level) (approximately 70 mv p-p). Base of Q17 approximately 40 mv p-p. CR23, Q17, Q18, Q19.
H		CRYSTAL FILTER SELECTIVITY		
H1	Center Frequency: Oscillator 200CD to INPUT of 302A (25 cps, 1 volt rms)	MAX INPUT VOLTAGE switch to 1 volt. RANGE switch to 1V MODE SELECTOR to NORMAL SCALE VALUE to RELATIVE	Determine center frequency of filter using half-power points. Tune 200CD for maximum reading of 302A meter. Adjust 0 db reference with REF ADJUST control Detune 200CD for the two -3 db points (f_a, f_b). $f_c = 1/2 (f_a + f_b)$ read f_a and f_b on 200CD oscillator.	

Table 5-3. Maintenance Checks and Adjustments (Cont'd)

Ref	Test Equipment and Connections	Important Control Settings	Measure - Adjust	Repair - Check - Replace
H2	Flat Top Characteristics: Same as in H1	Same as in H1	Tune 200CD to filter peak, record counter reading. Set 100% reference with REF ADJUST control for 1.0 volt on meter. Decrease frequency until meter reading drops by 1/2 division (1%). Record counter reading. Increase frequency until meter reading drops by 1/2 division (1%). Record frequency. Compare results with graphs shown.	
H3	70 cps Rejection: Same as in H1	MAX INPUT VOLTAGE switch to 1 volt RANGE switch to 1V	Tune 302A for peak response Set 100% reference with REF ADJUST control (1.0V) Change frequency of 200CD to 200 cps and 340 cps. 70 cps rejection is correct if meter reading less than .1 (below -80 db).	
H4	Final Filter Adjustment: The pass band characteristics (flat top) can be corrected slightly without changing any of the filter adjustment settings.			
H4.1	Narrow, Unsymmetrical Characteristic: An unsymmetrical response can be corrected by changing first R83 slightly, as shown in illustration. Correct further R57 and R58 to broaden the characteristic. CAUTION: DO NOT CHANGE any of the filter adjustments.			

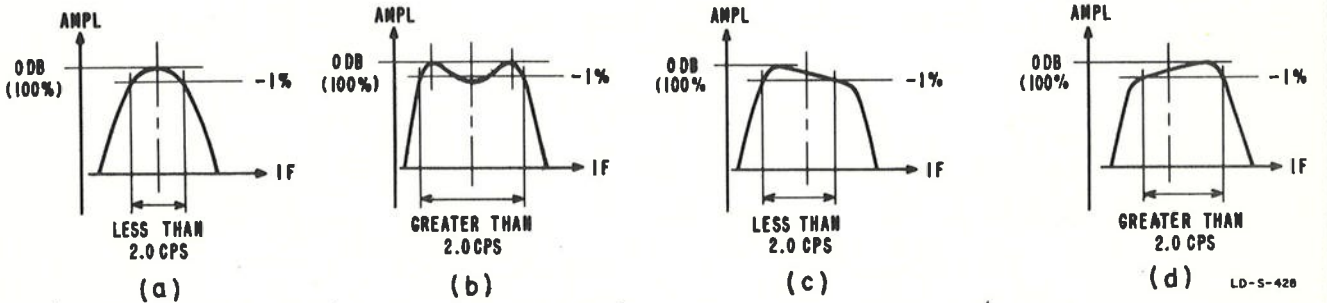


Table 5-3. Maintenance Checks and Adjustments (Cont'd)

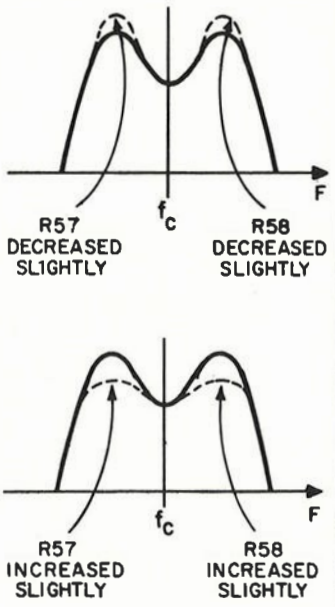
Ref	Test Equipment and Connections	Important Control Settings	Measure - Adjust	Repair - Check - Replace
H4.2	Narrow, Symmetrical Characteristics: Since the filter response is symmetrical, a broadening of the characteristics can be obtained by increasing R57 and R58 slightly as shown in illustration.			
J	AFC DISCRIMINATOR			
J1	Discriminator Response:			DISCRIM. OUTPUT + 0 -1 -2 IF FREQ. BIAS 200CD FREQ. 27 26 25 24 23 CPS RO If discriminator output is not -1.0 volt, check AFC BIAS. If negative response peak is more negative than -2V, check CR18. If output remains more positive than -1.0 volt, check CR17.
	Move yellow lead from center arm of AFC GAIN control to center arm of R129 (NORM BIAS ADJ) Connect dc meter to black/orange lead of R122 (AFC/ GAIN). Connect 200CD to INPUT (25 cps 1V) Connect pin J (orange lead) to pin B (green/white lead).	MAX INPUT VOLTAGE to 1 volt RANGE switch to 1V MODE SELECTOR to AFC Tune 302A to 25 cps	Vary 200CD frequency from 35 cps to 18 cps; read dc meter and compare with plotted discriminator response Set 200CD and 302A to 400 cps. Set 200CD to 600 cps and decrease toward 400 cps Correct discriminator output is -1.0 volt (bias) at 600 cps, decreasing continuously to -2.0 volt at negative resonance peak. Positive peak approximately -0.5 volt, separated by 2 cps from negative peak.	

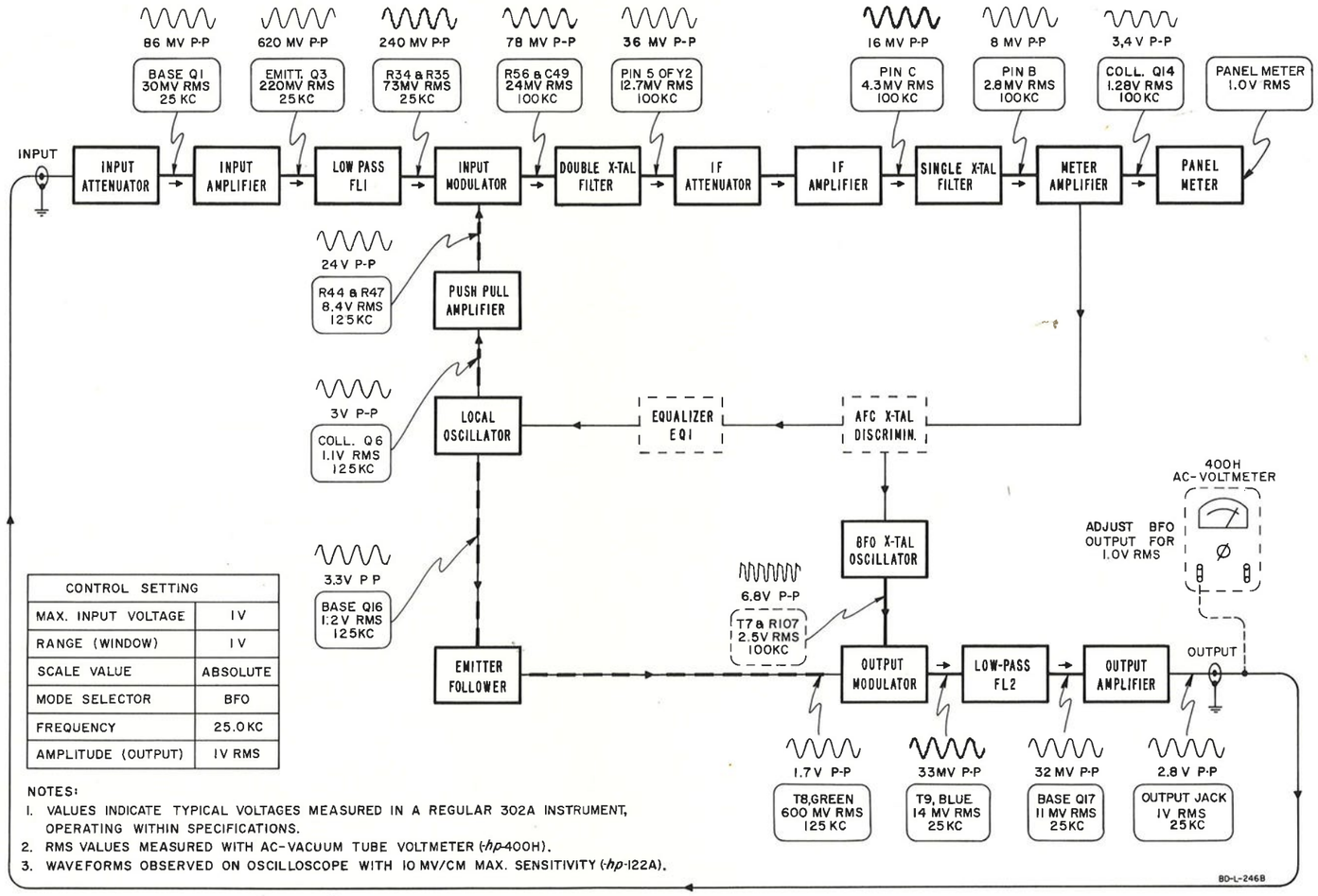
Table 5-3. Maintenance Checks and Adjustments (Cont'd)

Ref	Test Equipment and Connections	Important Control Settings	Measure - Adjust	Repair - Check - Replace
J2	Discriminator Gain: Same as J1	Same as J1	Discriminator gain is correct if AFC hold-in range is ±100 to 150 cps and unit is stable at 50 kc (i.e. no hunting).	Check -1.0 volt discriminator bias and adjust R131 (AFC Bias). Reconnect leads for normal operation
J3	Discriminator Bias:	MODE SELECTOR to NORMAL	DC bias at centerarm of R129 (Normal Bias) and R131 (AFC Bias). Correct bias voltage -1 volt ±2%	Check -15 volt supply and adjust R129 and R131 for correct bias.
L		INPUT ATTENUATOR		
L1	Attenuation: Connect 738A Voltmeter Calibrator to 302A INPUT.	MAX INPUT VOLTAGE at .03 volt. RANGE at 30 mv. SCALE VALUE switch to ABSOLUTE. MODE SELECTOR to NORMAL.	Apply .030 volt rms from 738A. Tune 302A (approximately 400 cps) and change MODE switch to AFC. Increase input signal and MAX INPUT VOLTAGE switch in 10 db steps (.03v -300v). Correct attenuation if meter reading within 5% of input voltage.	
L2	Frequency Response: Connect 200CD thru 350B attenuator to 302A INPUT. Set FREQUENCY to 400 cps. Monitor input to 302A with ac voltmeter (Model 400H). Adjust 200CD amplitude control for 0.1 volt as indicated on 400H.	MAX INPUT VOLTAGE at 1 volt. RANGE at 10 mv. SCALE VALUE switch to RELATIVE. MODE SELECTOR to AFC. Set 350B to 40 db attenuation.	Check 0.1 volt, 0.3 volt, 1.0 volt, 3.0 volt, and 10 volt positions at 400 cps and 50 kc by decreasing 350B attenuation in 10 db steps. Frequency response correct if 302A meter reading at 400 cps and at 50 kc remains within 5% for each position (input level constant, monitored with 400H). Note: Use REF ADJUST control to obtain a 1.0 volt meter reading in all switch positions.	Correct C3 for 0.1 volt C4 for 0.3 volt C1 for 1.0 volt C8 for 3.0 volt C2 for 10 volt range

Table 5-3. Maintenance Checks and Adjustments (Cont'd)

Ref	Test Equipment and Connections	Important Control Settings	Measure - Adjust	Repair - Check - Replace
M		IF ATTENUATOR		
	Connect 738A Voltmeter Calibrator to 302A INPUT.	MAX INPUT VOLTAGE switch to 0.3 volt RANGE to 0.3 volt SCALE VALUE to ABSOLUTE MODE SELECTOR to NORMAL	Apply 0.3 volt rms from 738A. Tune 302A (approximately 400 cps) and change MODE switch to AFC. Rotate MAX INPUT VOLTAGE switch clockwise in 10 db steps while decreasing (counterclockwise) RANGE switch in 10 db steps. IF attenuation correct if meter reading remains at 3.0 (±5%) for each setting.	
N		FREQUENCY CALIBRATION		
	524C/D to OUTPUT jack of 302A	MODE SELECTOR to BFO MAX INPUT VOLTAGE to 1 volt RANGE switch to 1 volt ZERO SET control centered.	ZERO-set instrument as indicated in figure 3-2. Check dial calibration by comparing dial setting with counter reading from 20 cps to 50 kc Tuning dial linearity correct if counter reading within ±(1% ±5 cps) of dial setting.	If dial linearity off, check dial range (20 cps to 50 kc). Adjust frequency dial range with C37. Adjust location of frequency range: low end with L6, high end with C37, C38. Note that the two adjustments are interacting
O		METER TRACKING		
	Connect 738A Voltmeter Calibrator to 302A INPUT.	MAX INPUT VOLTAGE to 1.0 volt RANGE to 1.0 volt SCALE VALUE to ABSOLUTE MODE SELECTOR to NORMAL.	Check meter tracking using 738A in "1V TRACK" function. Meter tracking correct if reading remains with 5% of 738A tracking voltage	If meter tracking is nonlinear, check gain of Q14; diodes CR12 and CR13.
P		DISTORTION		
	Connect 200CD thru a 1.5 kc low-pass filter to 302A INPUT Note: Any low-pass filter in the 20 cps to 10 kc range can be used, if it provides at least 80 db attenuation in the stop band. The signal frequency is then selected so that the harmonic components are filtered out.	MAX INPUT VOLTAGE to 1 volt. RANGE switch to 1v.	Tune 302A to 1 kc and adjust 200CD amplitude for 1.0 volt meter reading. Tune 302A to 2 kc and 3 kc. Distortion characteristics correct if 2nd and 3rd harmonic level below -75 db.	If harmonic level is above -75 db adjust R25 (Bias Adj.) for minimum distortion. Check input amplifier gain and Q1, Q2, Q3.

FIGURE 5-12
SIGNAL TRACING CHART



CONTROL SETTING	
MAX. INPUT VOLTAGE	1V
RANGE (WINDOW)	1V
SCALE VALUE	ABSOLUTE
MODE SELECTOR	BFO
FREQUENCY	25.0KC
AMPLITUDE (OUTPUT)	1V RMS

NOTES:
1. VALUES INDICATE TYPICAL VOLTAGES MEASURED IN A REGULAR 302A INSTRUMENT, OPERATING WITHIN SPECIFICATIONS.
2. RMS VALUES MEASURED WITH AC-VACUUM TUBE VOLTMETER (*hp*-400H).
3. WAVEFORMS OBSERVED ON OSCILLOSCOPE WITH 10 MV/CM MAX. SENSITIVITY (*hp*-122A).

Figure 5-12. Signal Tracing Chart

5-24. TROUBLESHOOTING.

5-25. Trouble may occur because of component failures. If a Model 302A is stored at extreme termperatures, some crystal parameters may vary and thus affect the performance of the instrument.

5-26. Before troubleshooting the instrument, become familiar with the principles of operation described in section IV of this manual. Localize the trouble in a systematic way (see paragraph 5-27). Typical checks and voltage values for all circuit sections operating normally are given in table 5-3 (Maintenance Checks and Adjustments). No adjustment should be reset if the instrument meets the specifications for a given check.

5-27. TROUBLE LOCALIZATION.

5-28. Troubles in the Model 302A can be localized conveniently by checking first the operation of the four key circuits (Power Supply, Square Wave Calibration, Local Oscillator and BFO Crystal Oscillator).

5-29. The remaining circuits are then checked systematically by feeding a bfo signal to the Model 302A INPUT and tracing the signal with the oscilloscope or voltmeter. Using the bfo signal as an input signal eliminates the need for afc.

5-30. If it is suspected that the selectivity of the bandpass filter is out of specifications, refer to table 5-3H (Crystal Filter Selectivity).

5-31. OPERATION CHECK OF KEY CIRCUITS. The following test equipment is needed for the operation check: DC Voltmeter, AC Voltmeter and Oscilloscope. For the requirements of the test equipment refer to table 5-1.

5-32. Table 5-4 lists checks and possible trouble symptoms related to the four key circuits.

5-33. SIGNAL TRACING. After the four key circuits have been checked for proper operation, trouble in the remaining circuits can be localized by using the arrangement shown in figure 5-12.

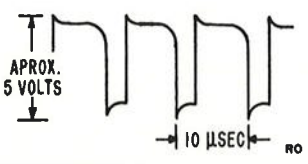
5-34. The values indicated on the chart are typical values and may vary slightly from instrument to instrument. Operate the instrument in the condition indicated on the chart, monitor the bfo output level (fed to the Model 302A INPUT) and trace the signal with a voltmeter (hp Model 400H or equivalent) or with an oscilloscope (hp Model 122A or equivalent).

5-35. Once a trouble has been localized within the circuit section, refer to paragraph 5-21, Maintenance Adjustment Procedure. Possible troubles within a circuit section and the adjustment procedure are listed systematically in table 5-3.

5-36. TUNING CAPACITOR ASSEMBLY.

5-37. Under normal operating conditions, the tuning assembly should not require maintenance. Shaft bearings are lubricated for the life of the instrument. The following procedures should be followed if replacement of tuning assembly parts becomes necessary. Figure 5-13A shows an exploded view of the tuning assembly. Special tool, hp No. T9138 alignment tool, is required for rotor alignment.

Table 5-4. Key Circuit Check

Circuit	Test Point	Measure	If Different, Check
Regulated Power Supply	Emitter of Q20	-15 volts ±0.2 volt	Switch S5 (ac battery) Fuse Diodes CR24, CR25 Breakdown diode CR27
Square Wave Calibrator	Centerarm of R39 (Cal. Voltage Adj.)	75 mv ±1 mv Frequency: 4-6 kc	Adjust R39 Breakdown diode CR27 Q4 and Q5
Local Oscillator	Junction or R44 and R47 (modulator bridge, located next to R45, Res. Carrier Bal.)	23 volts ±1 volt Frequency: 100-150 kc	Bridge Oscillator Q6 (3v p-p at collector of Q6) Diodes CR6, CR7 Q6, C40, C41 Diodes CR4, CR5
BFO Crystal	Junction of R107 and C92 (located in AFC-circuit section)		Limiter diode CR16 Q15 Crystal Y4

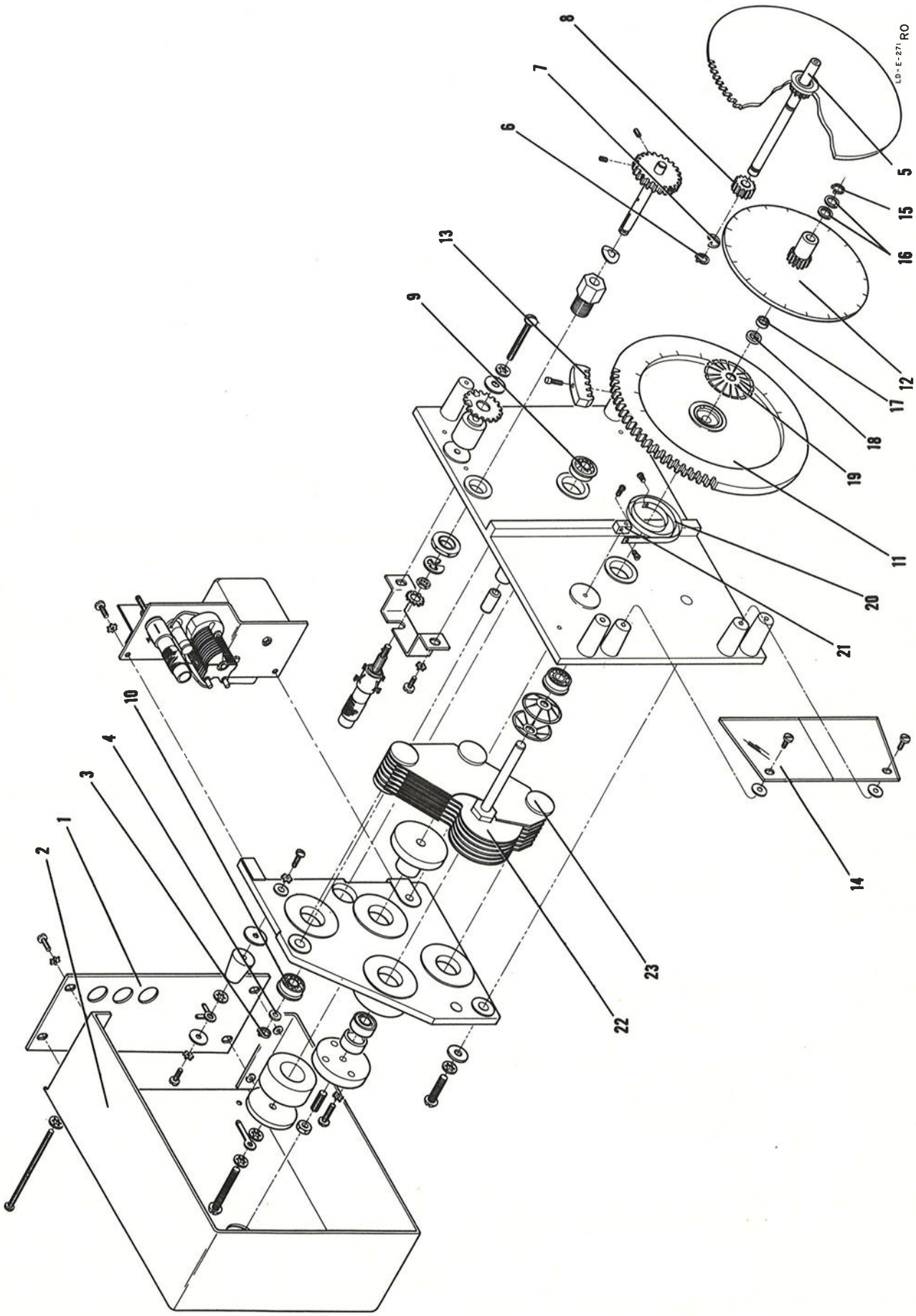


Figure 5-13A. Exploded View of Tuning Assembly

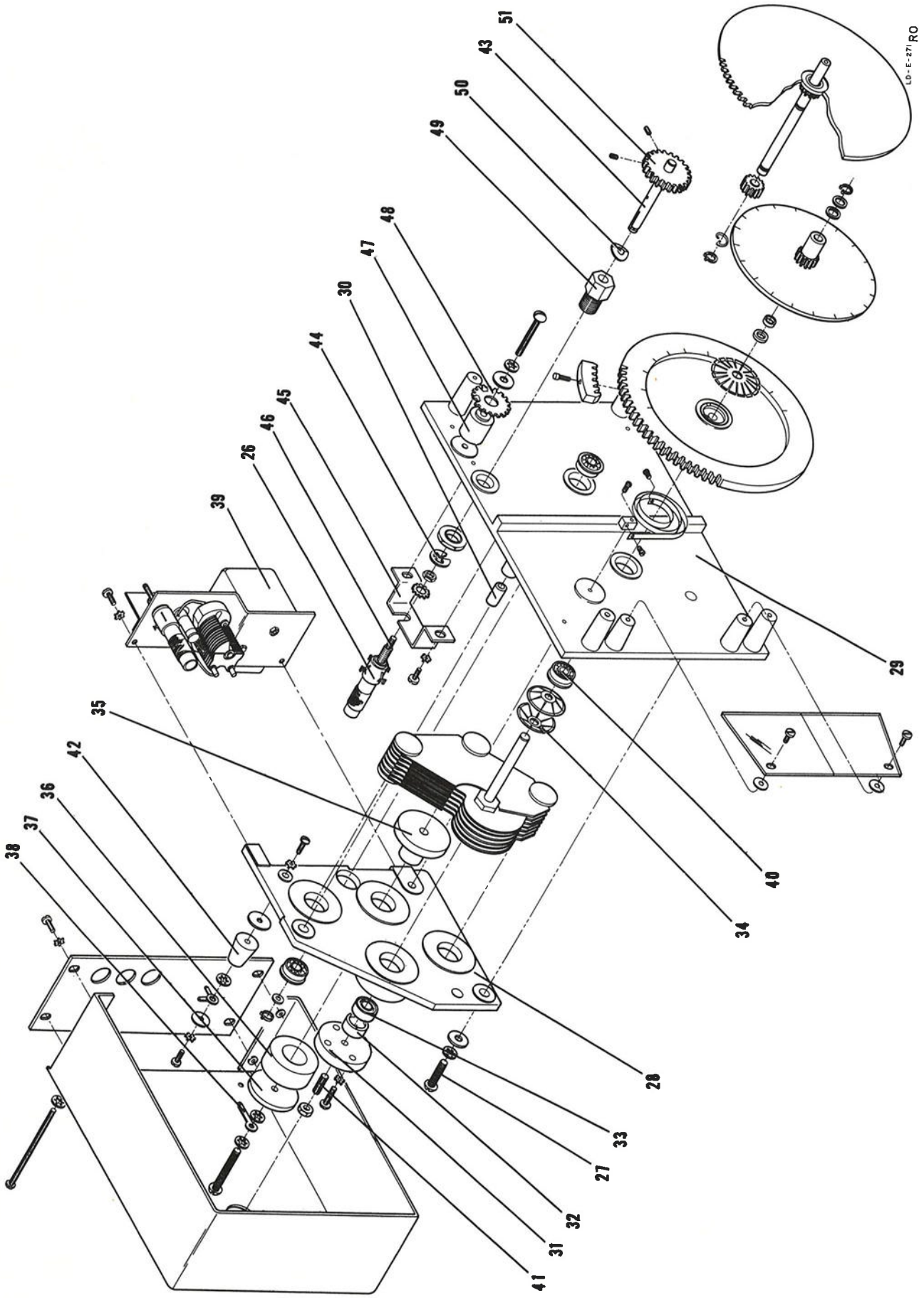


Figure 5-13B. Exploded View of Tuning Assembly

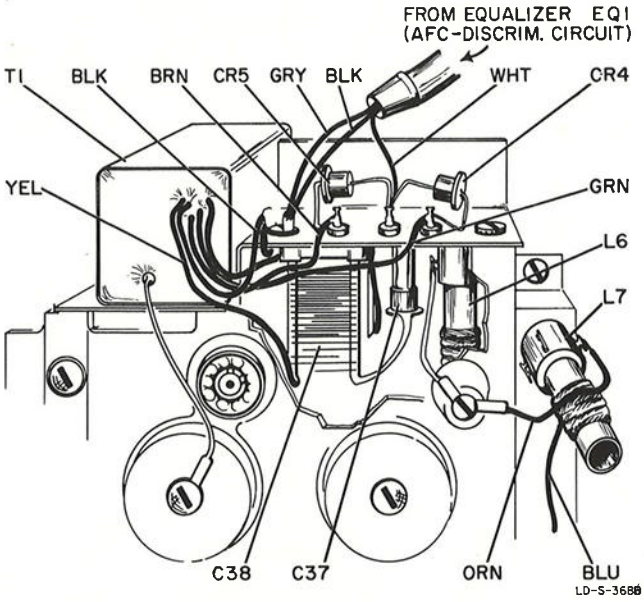


Figure 5-14. Tuning Assembly

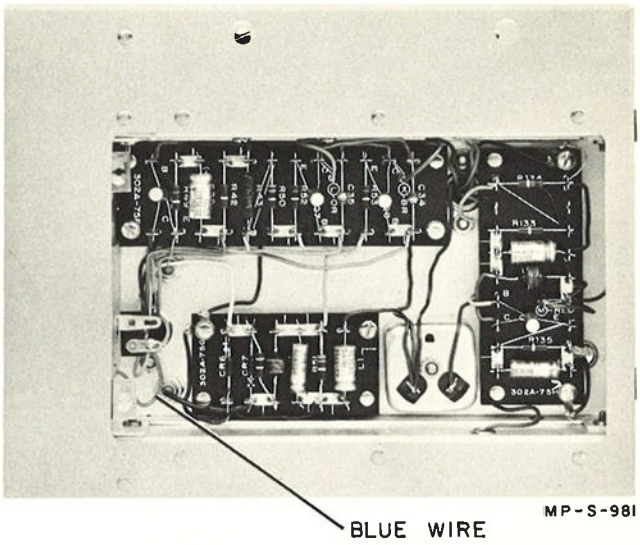


Figure 5-15. Local Oscillator Section

5-38. REMOVAL OF ASSEMBLY.

a. Open bottom cover of tuning assembly and unsolder equalizer output cable (white, grey and black leads) as shown in figure 5-14.

b. Remove side cover of 302A Wave Analyzer (local oscillator section, see figure 5-15) and unsolder blue lead from tie point.

c. Remove front panel knobs associated with the tuning capacitor assembly.

d. Unscrew the four round head screws holding the tuning assembly to the front panel. Remove assembly from instrument.

Note: Before proceeding with further disassembly, determine the necessary steps from table 5-5. The table lists a number of part replacements with associated disassembly and reassembly procedures.

5-39. REDUCTION GEAR REPLACEMENT.

a. Refer to figure 5-13 showing the exploded view of the tuning capacitor assembly.

b. Set FREQUENCY dial to 0.000 kc and place masking tape across two dials to keep their relative positions.

c. Remove back cover of tuning assembly.

d. Remove retaining ring (3) and washer (4) from reduction gear shaft (5).

e. Remove reduction gear shaft (5).

f. Remove retaining ring (6), loading spring (7) and loading gear (8) from reduction gear shaft.

g. Replace damaged parts.

h. Slip loading gear (8) and loading spring (7) on reduction gear shaft (5).

i. Place retaining ring (6) in groove located near loading gear.

j. Insert reduction gear assembly (5) in bearings (9) and (10) of both castings. To apply spring loading, proceed as follows:

(1) Insert reduction gear shaft gently and engage loading gear (8) with main frequency dial (11).

(2) With the loading gear engaged, rotate reduction gear (5) approximately 45-60 degrees clockwise and insert reduction gear further until both pinion gears mesh.

(3) Replace flat washer (4) and retaining ring (3).

Table 5-5. Repair Procedure Sequence

Repair of	Procedure Sequence
Main Dial Assembly	Reduction Gear Repair
Vernier Dial Assembly	Frequency Dial Repair Rotor Realignment Assembly Pretuning Reinstalling Assembly
Reduction Gear	Reduction Gear Repair
Ball Bearing	Assembly Pretuning Reinstalling Assembly
Zero Set Assembly	Zero Set Repair Assembly Pretuning Reinstalling Assembly
Rotor Bearings	Reduction Gear Repair
Rotor	Frequency Dial Repair
Stator	Rotor Repair Rotor Realignment Assembly Pretuning Reinstalling Assembly

5-40. FREQUENCY DIAL REPAIR.

a. Refer to figure 5-13A/B.

b. Disassemble reduction gear assembly by following steps a through f of paragraph 5-39.

c. Remove dial window (14).

d. Remove tape holding the two frequency dials in fixed position.

e. Remove retaining ring (15), flat washers (16) and vernier dial (12) from rotor shaft.

f. Remove spacer (17), flat washer (18) and compression washer (19).

Note

If damaged part can be replaced after completion of step f, do not continue with disassembly, thus avoiding rotor realignment. Proceed with step n of paragraph 5-40.

g. Remove rotor grounding spring (20) from support (21).

h. Engage rotor (22) fully into stator (23) and secure rotor position with masking tape placed across stator.

i. Loosen cap screw of main frequency dial hub (11) and remove dial from rotor shaft.

j. Replace damaged parts.

k. Place main frequency dial on rotor shaft. DO NOT tighten cap screw (step c of paragraph 5-44).

m. Fasten rotor grounding spring (20) to support (21).

n. Place compression washer (19), flat washer (18) and spacer (17) on rotor shaft.

p. Insert vernier dial (12), flat washers (16) and retaining ring (15).

q. Set frequency dials to 50.0 kc and secure position with masking tape.

r. Mount dial window (14), placing flat washer between dial and casting.

s. Proceed with rotor alignment (paragraph 5-44).

5-41. ROTOR (STATOR) REPAIR.

a. Disassemble reduction gear assembly following the first six steps of paragraph 5-39.

b. Disassemble frequency dial assembly following the first six steps of paragraph 5-40.

c. Disconnect orange lead from Zero Set Coil (26).

d. Remove three round head screws (27) holding rear casting (28) to front casting (29).

e. Tilt tuning assembly with rear casting facing upwards (provide clearance for rotor shaft!!).

f. Carefully separate rear casting from front casting WITHOUT applying any twisting torque that might damage the stator or rotor blades. Note that stator and rotor are removed simultaneously.

Note: Keep clear of Zero Set Coil (26)

g. Remove two centering pivots (30).

h. Remove two compression washers (34) and gently separate rotor from stator.

i. Remove rotor adjusting plate (31), slider (32) and bearing (33).

j. Proceed with parts replacement (step p, paragraph 5-41), if stator does not need repair.

k. Remove screws holding the three stator clamp washers (35) to stator.

m. Remove insulator washer (36) and stator insulators (37) from stator.

n. Gently remove stator from casting.

p. Replace damaged parts.

q. Place stator insulator (37) on bosses of stator (23).

r. Insert stator with stator insulator gently into rear casting.

s. With stator inserted in rear casting, place insulator washer (36) on stator insulator (37).

t. Mount stator clamp washer (35) with round head screws using internal lock washers.

Note

Mount solder lug (38) on capacitor stud, located opposite transformer of assembly (39).

u. Grease front rotor bearing (40) with lubriplate and insert bearing into front casting.

v. Insert rotor into rear rotor bearing housing (bearing will be inserted later) and mesh rotor carefully with stator.

w. Insert rear rotor bearing (33) (greased with lubriplate) and slider (32) with "ball" facing away from rotor.

x. Mount rotor adjusting plate (31).

y. Set rotor centering adjustment screw (41) so that rotor blades clear stator blades while pressing rotor shaft by hand against rotor adjusting plate (31). Do not lock yet. (Final centering done electrically in assembly pretuning.)

Note

The preliminary centering operation of step 5 is important to avoid damage of the stator or rotor plates when reassembling the two castings.

z. Insert two centering pivots (30) into two mounting holes of front casting plate.

aa. Place the two compression washers (34) on rotor shaft and carefully engage the two casting plates.

ab. With the two casting plates engaged, rotate rotor fully clockwise and secure rotor position with masking tape across stator blades.

Note: Place front casting plate (29) horizontally on its four mounting bosses (provide clearance for rotor shaft).

ac. Assemble the two castings and secure with three round head screws.

ad. Connect orange lead of Zero Set coil (26) to "V" type solder lug of standoff insulator (42).

ae. Reassemble frequency dial assembly by following steps k through s of paragraph 5-40.

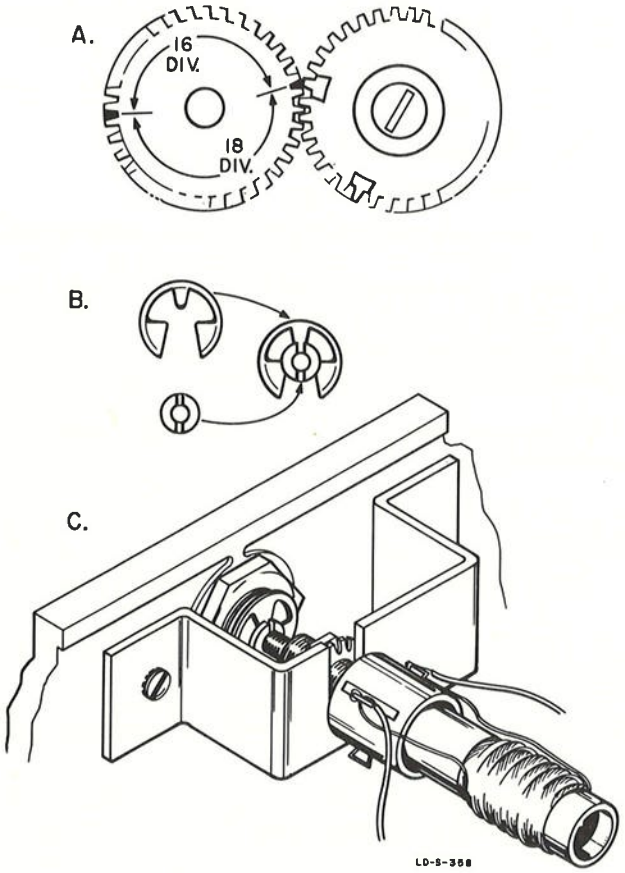


Figure 5-16. Zero Set Assembly

5-42. ZERO SET ASSEMBLY REPAIR.

5-43. Zero set coil L6 (26) can be replaced without disengaging the zero set drive. If gears accidentally disengage, the proper relationship can be re-established as indicated in step b of paragraph 5-43.

a. Unsolder orange lead from tie point on standoff insulator (42).

b. Turn Zero Set shaft (43) fully clockwise (until stopped by gear stop). Secure this gear position by placing a piece of masking tape across the two gears.

c. Remove E-shaped retaining ring (44).

d. Remove coil bracket (45) from casting.

e. Replace damaged coil.

f. Mount replacement coil in bracket.

Note: Insert coil fully into opening of bracket before tightening locking nut. See figure 5-16.

g. Turn coil slug until spiral pin (46) extends approximately 1/4 inch from coil bushing.

h. Insert coil shaft (26) into Zero Set shaft. Spiral pin should clear the brass bushing surface by approximately 1/64 inch, with coil bracket (45) held tightly against casting. If clearance differs greatly from 1/64 inch, turn coil shaft 1/2 turn clockwise or counterclockwise.

i. Mount coil bracket (45) to casting.

j. Insert E-shaped retaining ring (44).

k. Remove masking tape from zero set gear assembly and turn Zero Set shaft to its counterclockwise stop. While turning Zero Set shaft check mechanical alignment of coil shaft. Check correct number of turns between the two mechanical stops (11-1/4 turns).

Note

Check that both stops are positively controlled by the gear drive stops and not by the coil slug. If necessary repeat steps g through k.

m. Reconnect orange lead to solder lug on ceramic standoff insulator (42).

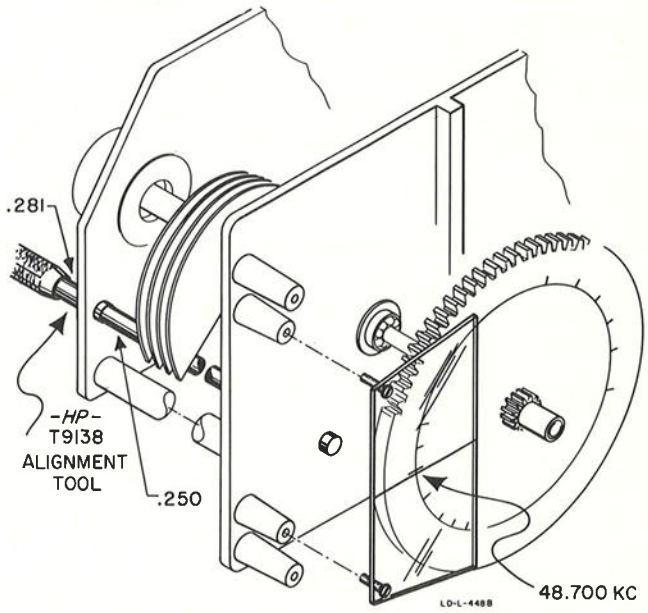


Figure 5-17. Rotor Alignment

5-44. ROTOR ALIGNMENT.

a. Turn the two frequency dials to 48.700 kc and place a piece of masking tape across the dials to hold the reading.

b. Insert alignment rod (hp T9138) into the .281 inch diameter holes of the two castings. Remove tape from rotor and rotate rotor until the flat edge of the plates rests gently against the rod. Refer to figure 5-17.

c. Edge the main dial hub out until the main dial face clears the window by approximately 1/32 inch. Secure the socket head screw tightly and remove the tape across the dials.

d. Check setting of rotor. Turn rotor clockwise and then back it again gently against alignment rod. DO NOT FORCE. The dial reading should be within 48.700 ±15 (cycles/second). Remove alignment tool.

e. Spin the frequency dial to approximately 25 kc. Spin the dials. If they tend to coast, remove retaining ring (15) from rotor shaft and add 0.01 inch washer. Lubricate the vernier pinion by applying a small amount of lubriplate to the rotor shaft. Replace retaining ring.

f. Reassemble reduction gear assembly, following steps h through j, paragraph 5-39.

5-45. ASSEMBLY PRETUNING.

5-46. The pretuning consists of centering the rotor with respect to the stator, adjusting L7 for the correct range of ZERO SET and aligning the assembly for the correct frequency range.

a. Make the following clip-lead connections:

(1) Blue lead from coil L6 (ZERO SET) to tie point in local oscillator section.

(2) Ground lead connecting the tuning assembly casting to the 302A instrument chassis ground.

(3) Junction of diodes CR4 and CR5 to the center-arm of R129 (NORMAL BIAS).

(4) Connect counter (524C/D) to junction of R44 and R47 in modulator bridge (rear right hand corner on top chassis).

b. Set ZERO SET control 5-1/2 turns from counter-clockwise stop.

c. Set FREQUENCY dial to 25.0 kc.

d. Set rotor centering screw with allen wrench for maximum frequency reading on counter. Check frequency maximum after locking the setscrew. Repeat step if necessary. Note: The centering of the rotor is critical since any off-center position of the rotor with respect to the stator may cause non-linear frequency tracking across the band.

e. Set FREQUENCY dial to 0.0 kc.

f. Adjust L7 for 100.000 kc reading on counter. (ZERO SET control in its center range position, see step b.)

g. Set FREQUENCY dial to 50.0 kc. Record error (d_g) (for example, -600 cps for 149.400 kc).

h. Adjust C38 for 150.0 kc +2/3 of d_g (frequency error of step g) (that is +400 cps).

i. Set FREQUENCY dial to 0.0 kc and adjust L7 for 100.000 kc.

j. Set FREQUENCY dial to 50.0 kc. Record error (d_{11})$_j$ (for example, -21 cps for 149.979 kc).

k. Correct with C37 for 150.0 kc +2/3 of d_j frequency error of step j (that is, +14 cps).

m. Set FREQUENCY dial to 0.0 kc and adjust L7 for 100.000 kc.

n. Continue until correction necessary at 150.0 kc is less than 15 cps.

p. Check frequency tracking. The FREQUENCY dial setting readings are compared with the counter readings. Tracking Accuracy: 0.0 kc to 1.0 kc ± 5 cps, 1.0 kc to 50.0 kc ±1%.

5-47. REINSTALLING OF ASSEMBLY.

a. Disconnect all clip lead connections.

b. Replace back cover of assembly, feeding blue lead through metal grommet.

c. Insert assembly into 302A instrument and fasten assembly to front panel.

d. Connect equalizer output cable to junction of diodes CR4 and CR5, see figure 5-14.

e. Replace bottom cover of tuning assembly.

f. Replace front panel knobs associated with tuning assembly.

g. Connect blue lead to tie point in local oscillator section.

5-48. SWITCH ASSEMBLIES.

5-49. There are three switch assemblies in the 302A Wave Analyzer: (a) Input Attenuator, (b) IF Attenuator and (c) Mode Selector. All switches are easily accessible and can be checked for continuity or open circuit without removal from the instrument.

a. Input Attenuator. (MAX. INPUT VOLTAGE) Refer to figure 5-18 for the parts identification of the switch assembly.

b. IF Attenuator. (RANGE) Refer to figure 5-19 for the parts identifications of the IF attenuator switch assembly. After removing the assembly cover, the resistors of the switch assembly are accessible for testing. The IF Attenuator switch can be removed as an assembly by removing the knob, loosening the two setscrews in the hub, and removing switch mounting hardware.

c. Mode Selector. Refer to figure 5-20 for the switch assembly and the parts identification. The MODE SELECTOR switch assembly can be removed after unsoldering the connecting leads.

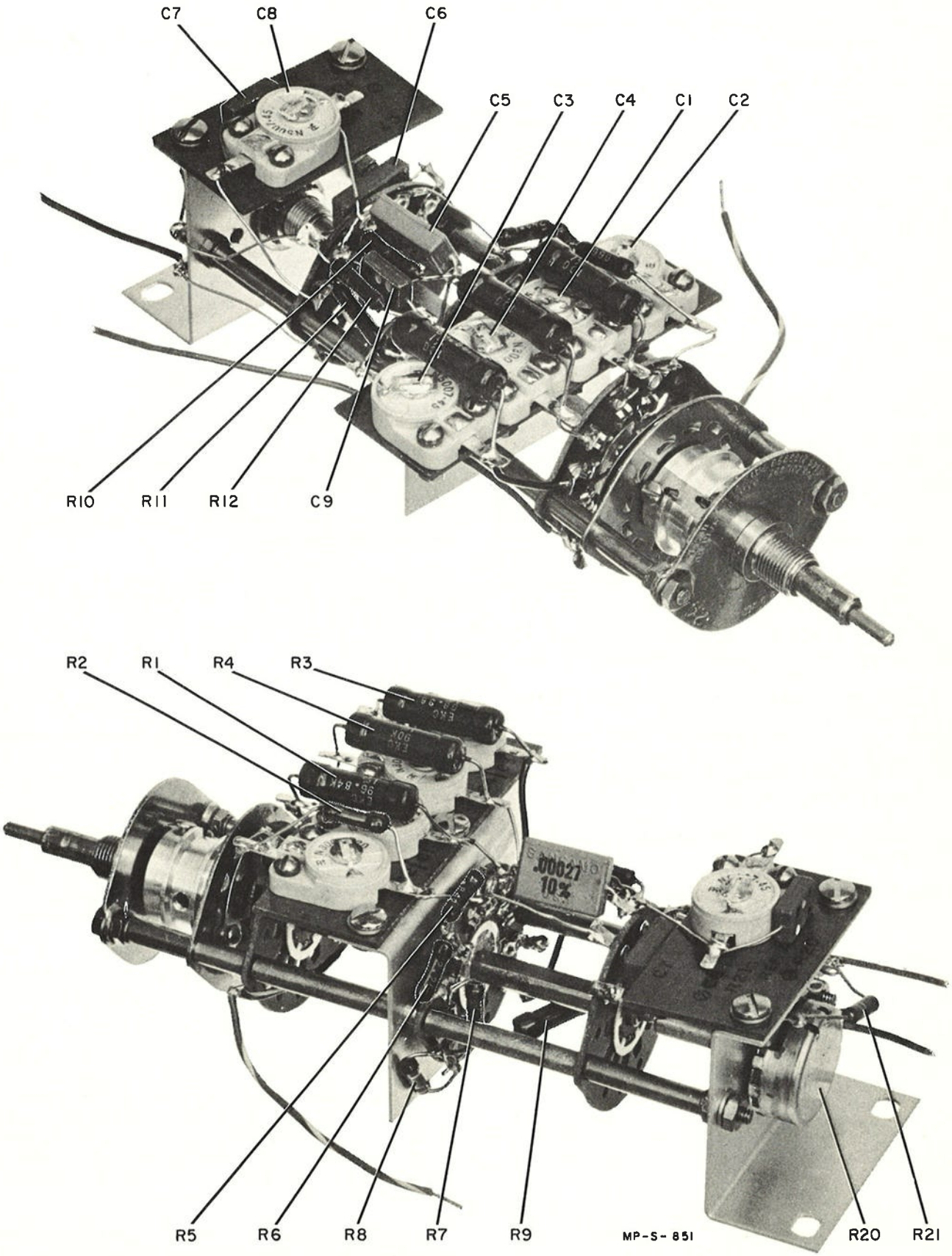


Figure 5-18. Input Attenuator Assembly

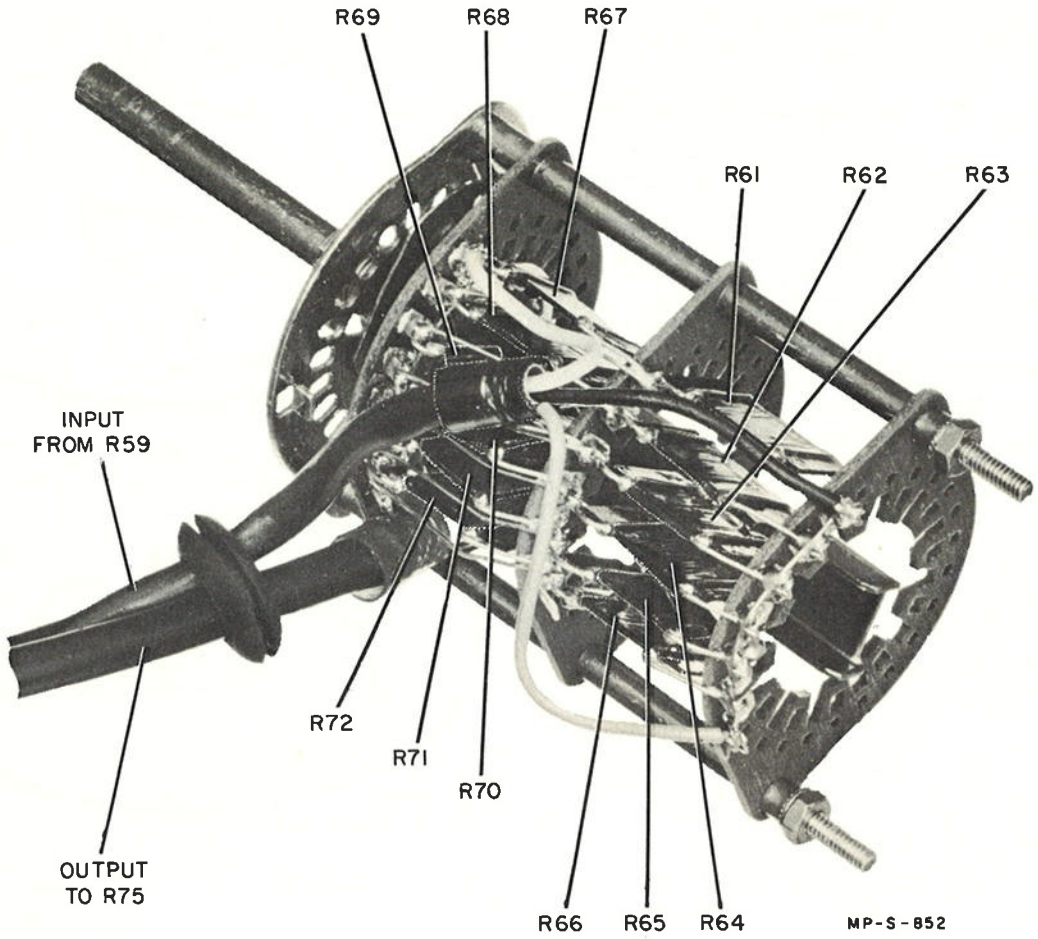


Figure 5-19. IF Attenuator Assembly

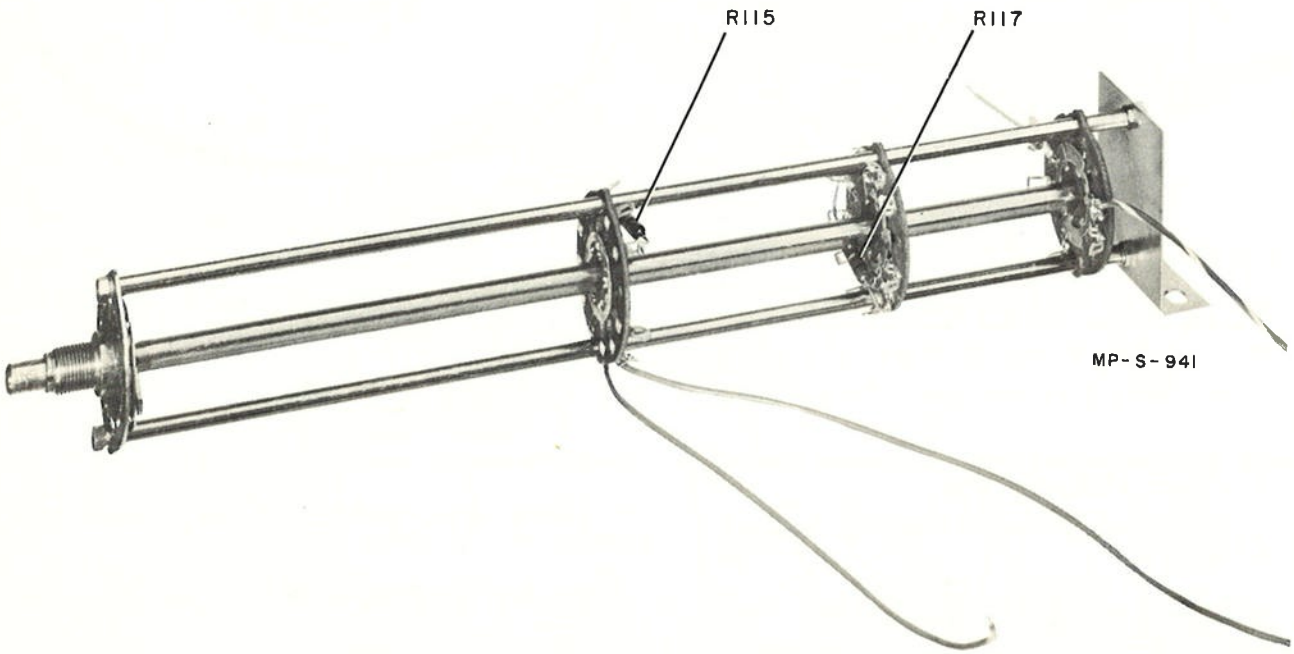


Figure 5-20. Mode Selector Switch Assembly

5-50. DIAL DRIVE CABLE REPLACEMENT.

5-51. The following special tools and materials are required to replace the dial cable in the 302A Wave Aanalyzer:

a. Dial cable, 4 feet long, hp stock No. 8160-0003 or equivalent.

b. Locking rod #25 drill diameter (0.149 inch).

5-52. DISASSEMBLY OF RANGE SWITCH DIAL.

a. Remove push rod, activating the calibrator switch. Turn RANGE switch fully counterclockwise, loosen the two allen screws of collar and remove rod.

b. Remove knob of RANGE switch.

c. Remove three phillips screws holding the RANGE switch assembly to the front panel.

d. Remove switch assembly carefully from the front panel by tilting it, so RANGE switch dial faces upwards. Note that the two cables connected to the switch assembly do not need to be unsoldered.

e. Refer to figure 5-21 and remove dial assembly from switch shaft by loosening allen screws of hub (1).

f. Remove nut (2) dial screen (4) and dial assembly (6) from hub (1).

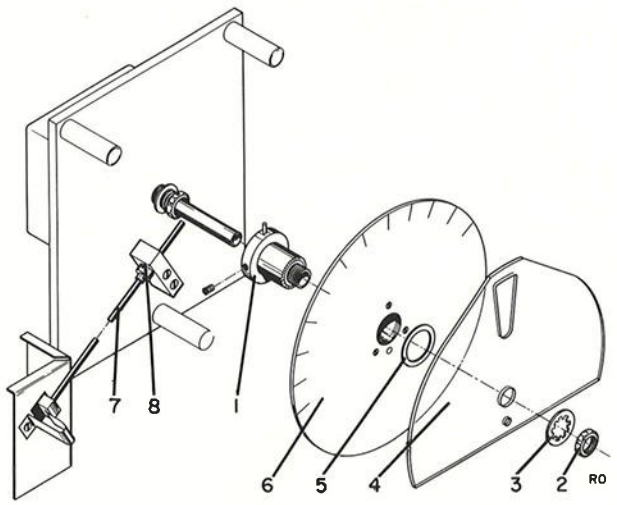


Figure 5-21. Exploded View Dial Assembly

5-53. INSERTION OF REPLACEMENT CABLE.

a. Remove remaining parts of broken dial cable.

b. Refer to figure 5-22A and insert new dial cable as shown.

c. Wind both dial cable ends 1-1/4 turns around idler hub as shown in figure 5-22B.

d. Tape both ends individually to dial disc as shown in figure 5-22C.

5-54. REPLACING OF RANGE SWITCH DIAL.

a. Refer to figure 5-21 and replace dial assembly on switch shaft. Note that the final positioning of the dial screen is set later.

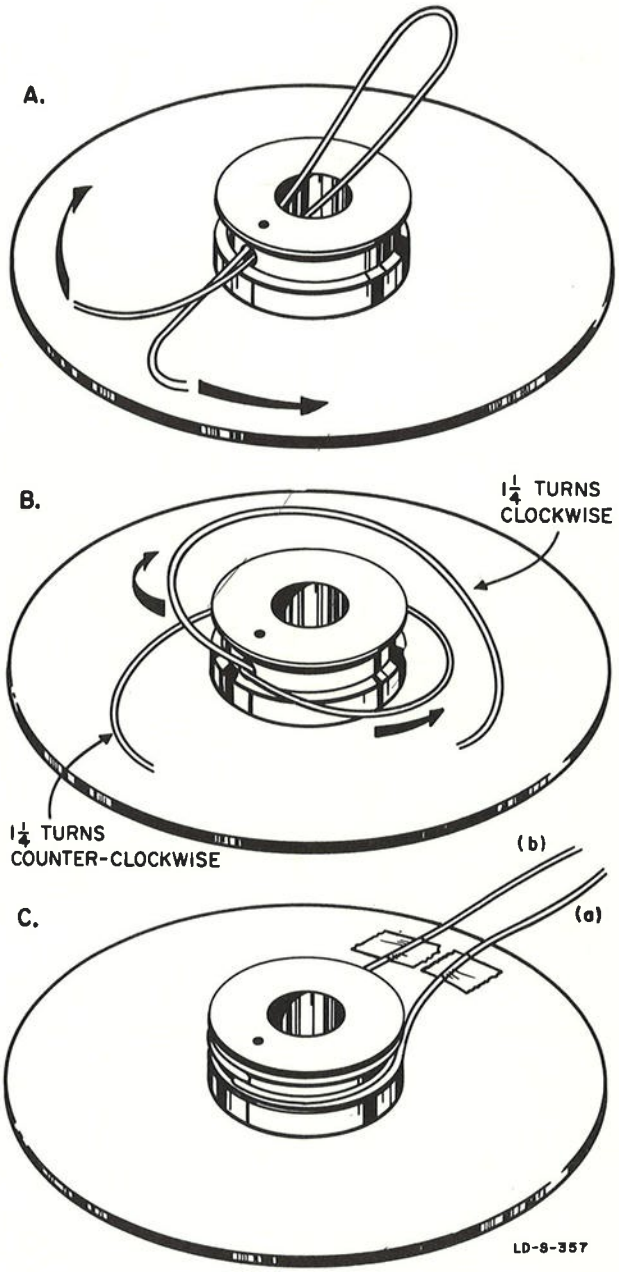


Figure 5-22. Dial Cable Lacing

b. Reinstall switch assembly and mount it to the front panel (three phillips screws).

5-55. FINAL INSTALLATION OF DIAL CABLE (LACING).

a. Place instrument on its top.

b. Rotate MAX. INPUT VOLTAGE switch fully counterclockwise (0.03).

c. Remove remaining parts of broken dial cable.

d. Refer to figure 5-23.

e. Insert locking rod through front panel.

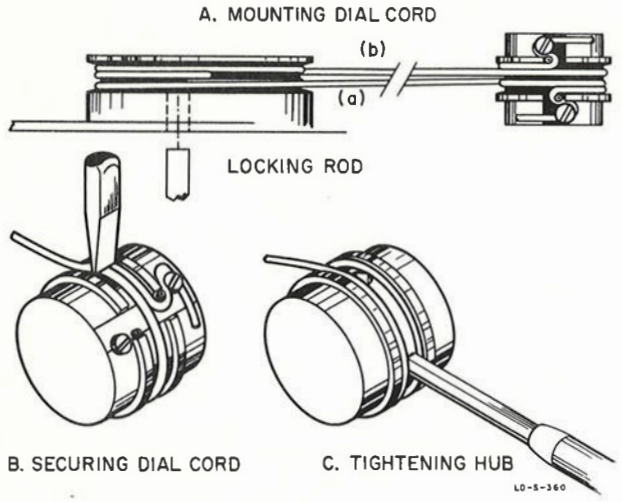


Figure 5-23. Installation of Dial Cable

f. Wind cable end (a), adjacent to the dial, around hub of attenuator switch as shown in figure 5-23. Pull cable tightly around hub and hold it in position with screwdriver. Lace cable around drive pin and fillister head screw. Tighten fillister head screw.

g. Repeat step f for cable end (b).

5-56. FINAL POSITIONING OF RANGE SWITCH DIAL.

a. Insert allen wrench (#8) between adjacent dial cable turns.

b. Set MAX. INPUT VOLTAGE switch to 300V position.

c. Loosen both setscrews of hub as shown in figure 5-23C.

d. Rotate hub with allen wrench until RANGE switch dial appears centered as shown in figure 5-24.

e. Position dial screen window, by loosening slightly locking nut (2) (figure 5-21). Adjust screen so window appears centered in 300V position as shown in figure 5-24. Tighten locking nut.

f. Tighten both allen screws of attenuator switch hub.

g. Cut off excess cable.

h. Replace push rod (7) and collar (8).

i. Rotate RANGE switch to 300V position.

j. Press rod gently against activating spring, and tighten allen screws of collar (8).

k. Check action of RANGE switch in CAL 1V position, check action of MAX INPUT VOLTAGE switch and the positioning of the dial.

5-57. EQUALIZER AND LOW PASS FILTER REPLACEMENT.

5-58. Equalizer EQ1 and Low Pass Filters FL1 and FL2 are replaced as assemblies. Refer to figure 5-11.

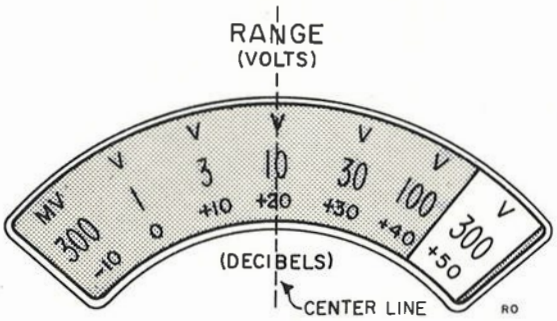
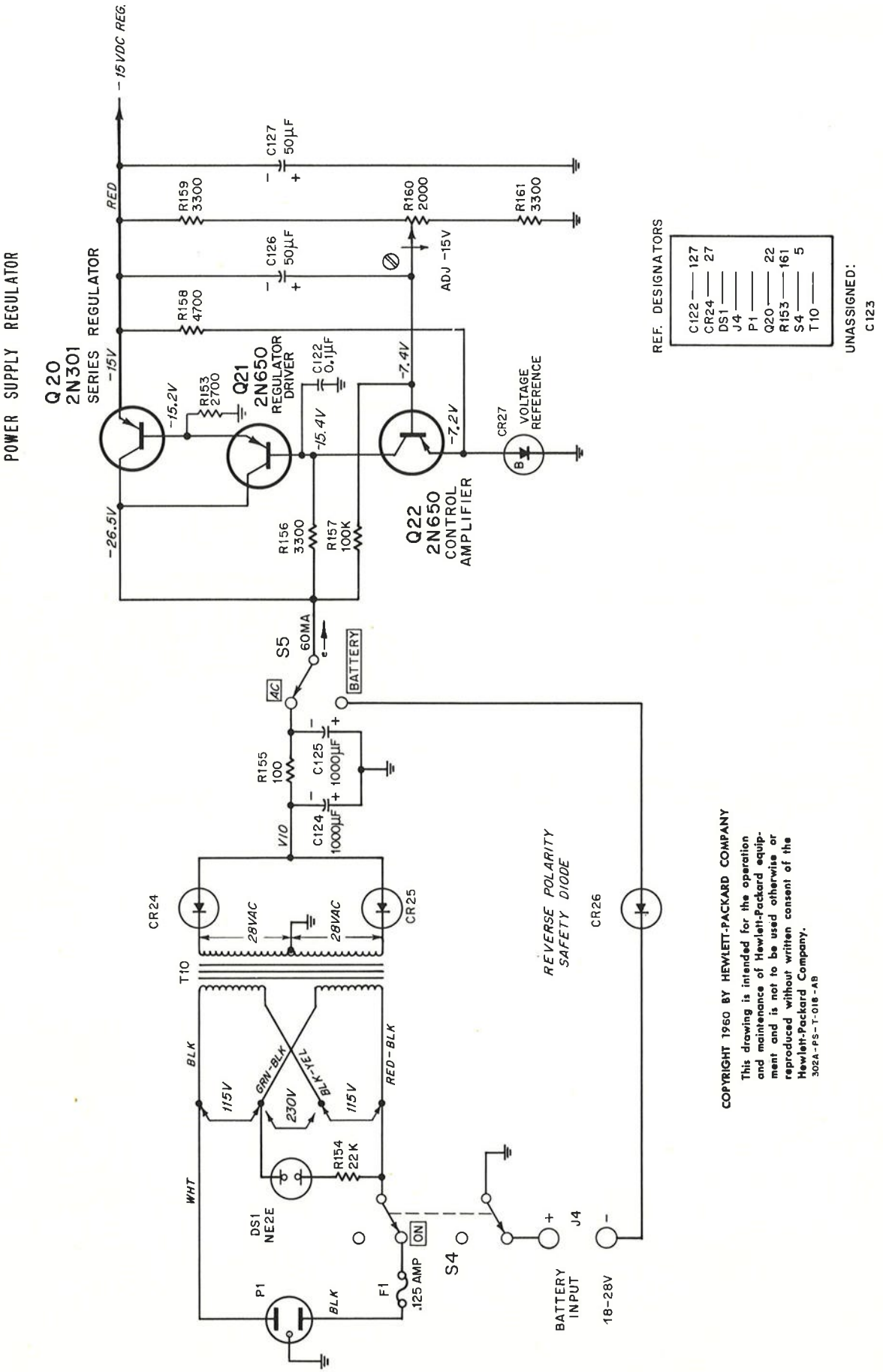


Figure 5-24. Centering Dial



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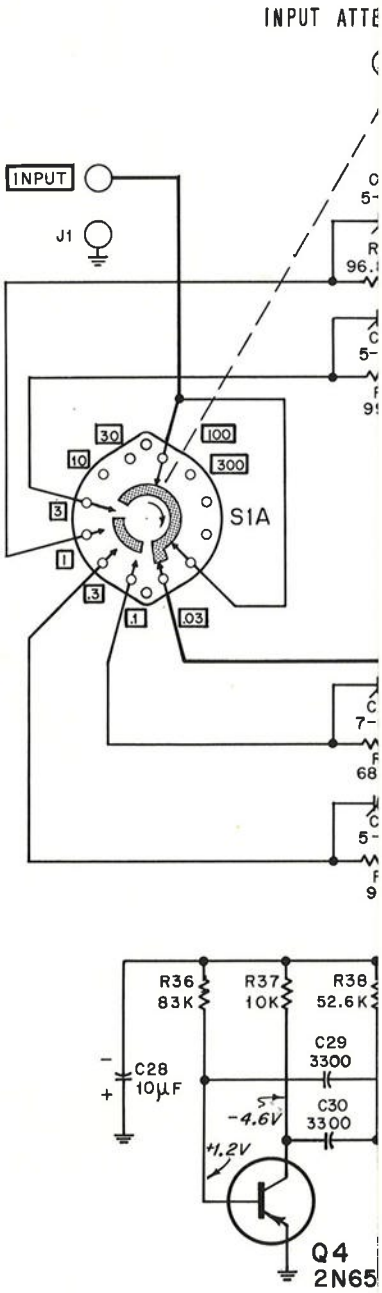
302A-PS-T-018-AB

Figure 5-25. Power Supply

FIGURE 5-26
INPUT AMPLIFIER AND
LOCAL OSCILLATOR



REF. DESIGNATORS

C1	41
CR1	12
FL1	
J1	
L1	8
Q1	8
R1	53
S1, 2B, 6	
T1	4

UNASSIGNED:
C10, 11, 27

R31

DELETED:
C20 - 26

L2 - 4

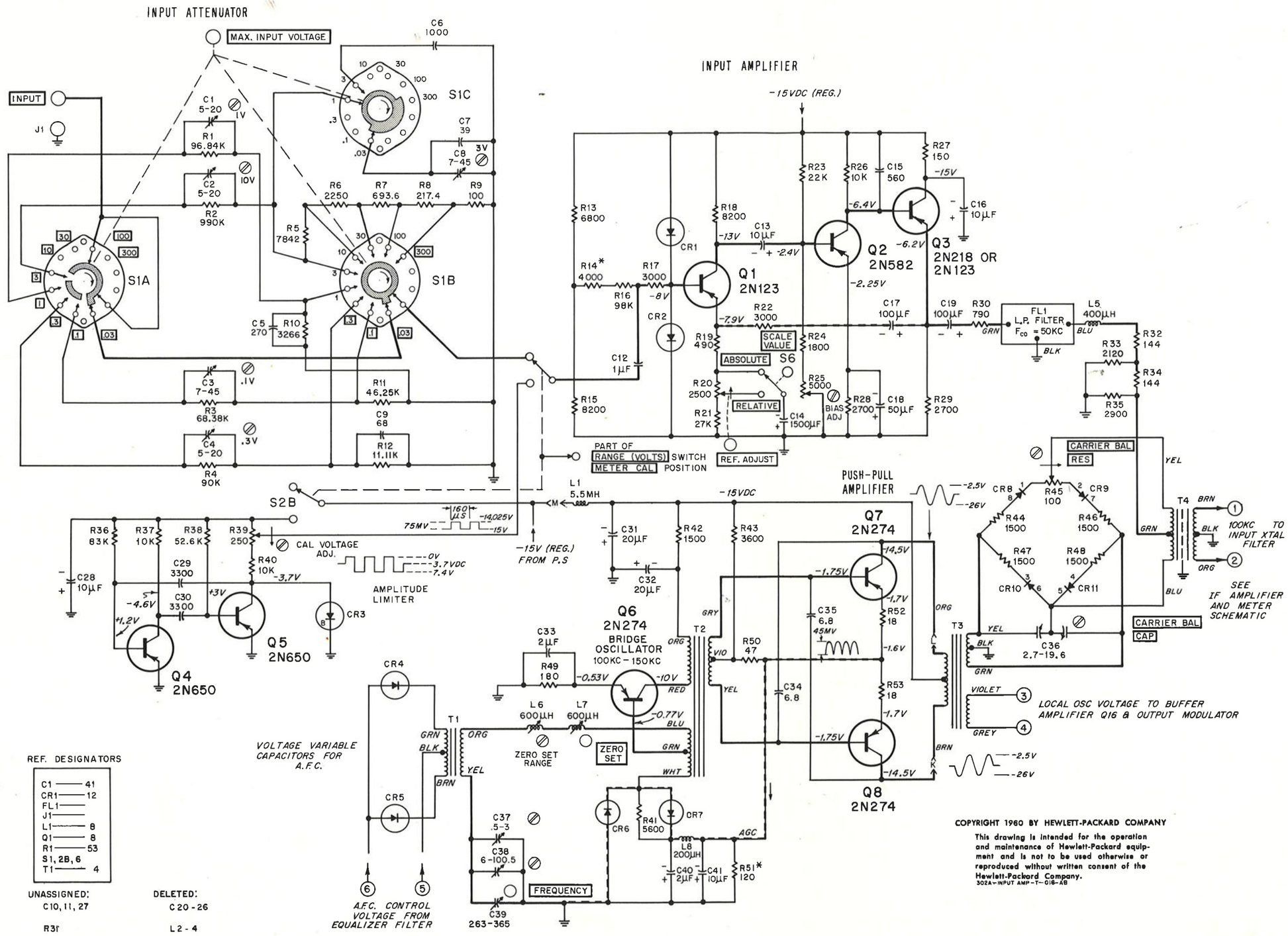
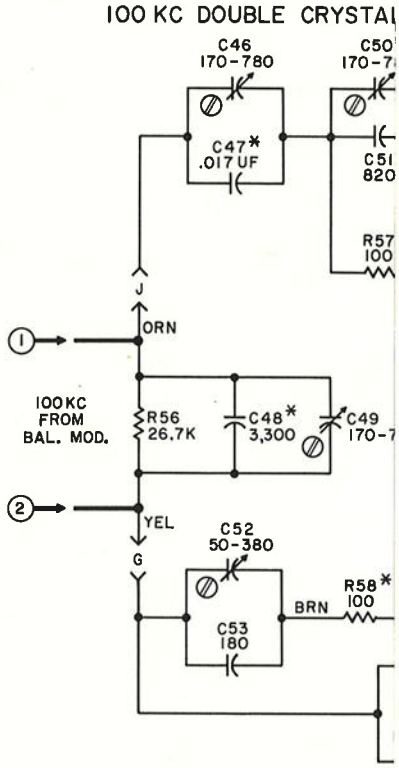


Figure 5-26. Input Amplifier and Local Oscillator

FIGURE 5-27
IF/METER AMPLIFIER



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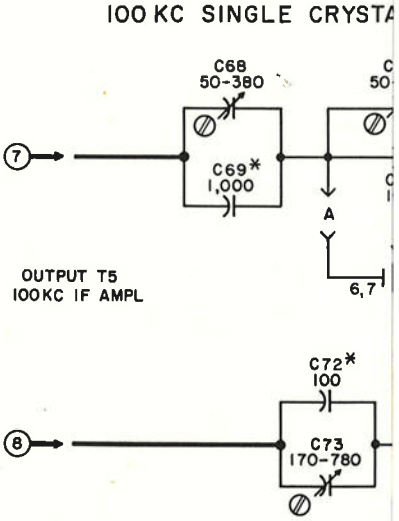
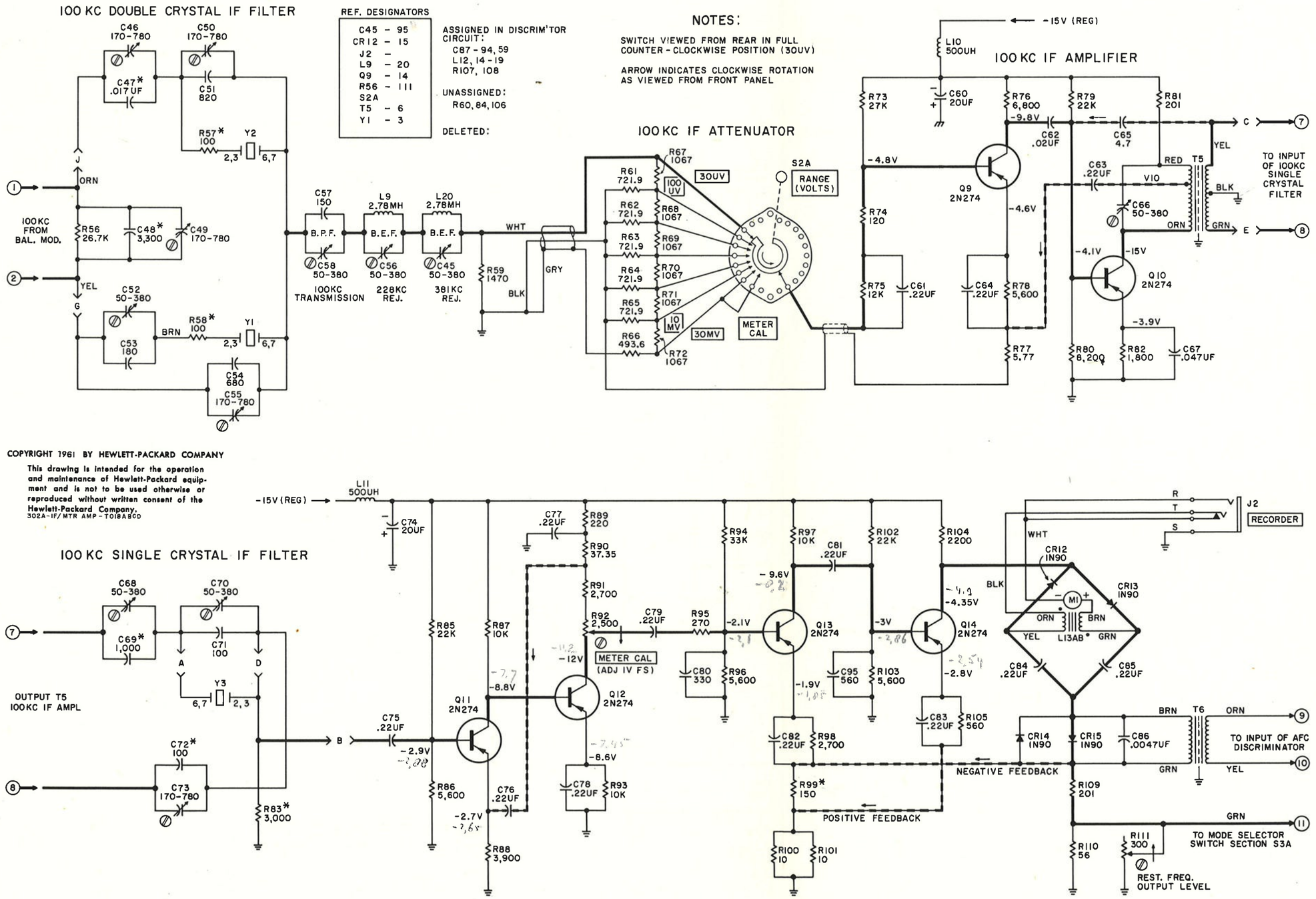
302A-IF/MTR AMP-T01BABCD





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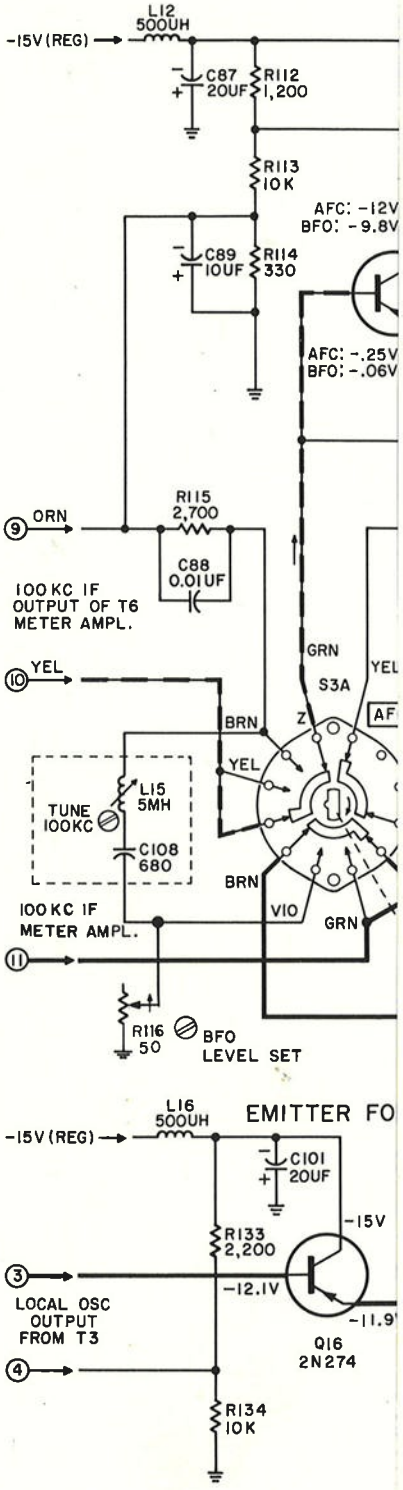
302A-IF/MTR AMP-T01BA5CD

Figure 5-27. IF/Meter Amplifier

FIGURE 5-28
AFC/BFO CIRCUITS AND OUTPUT AMPLIFIER



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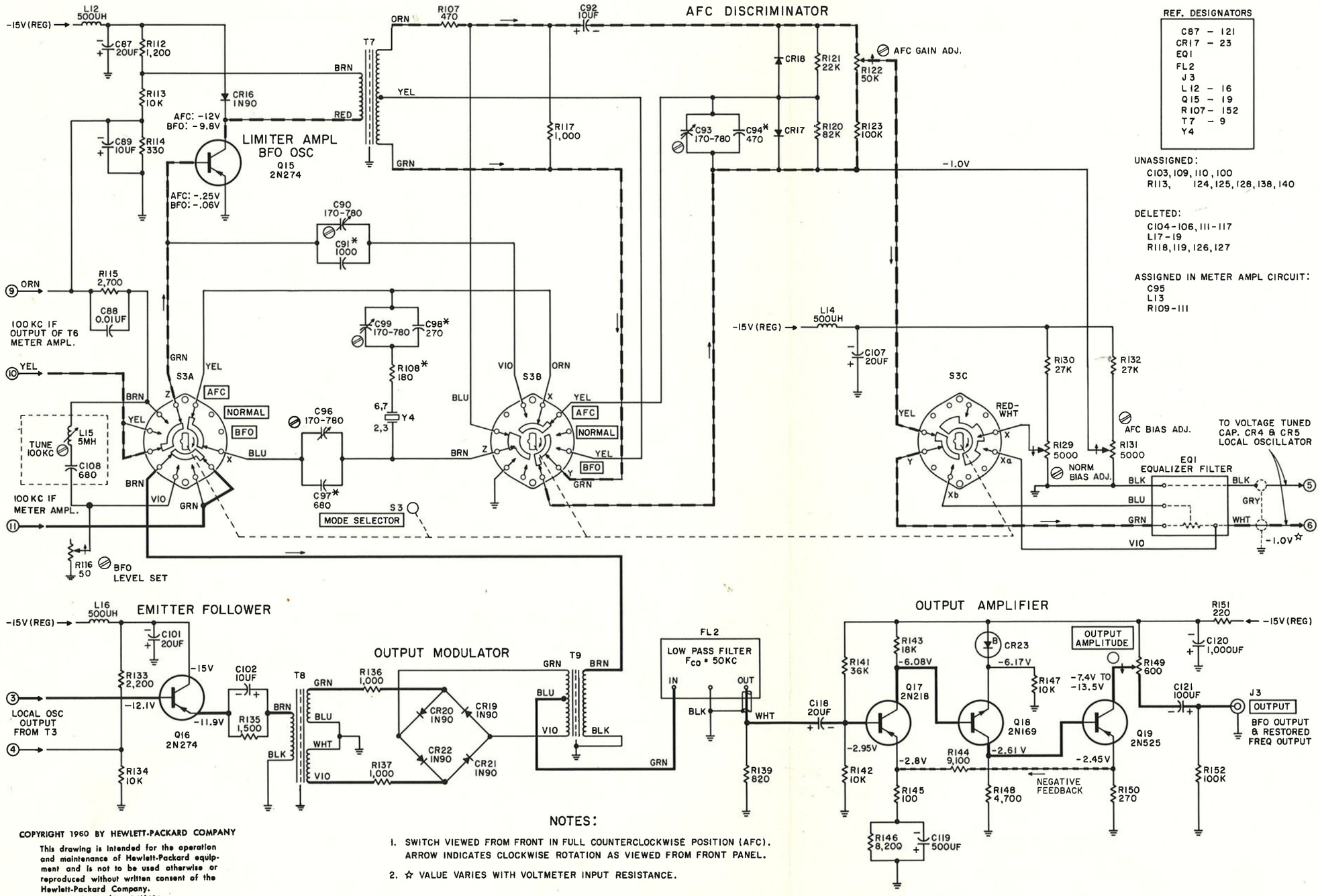
302A - AFC/BFO CIR'TS - T 01SABC



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302A - AFC/BFO CIR'TS - T 018ABC

NOTES:

1. SWITCH VIEWED FROM FRONT IN FULL COUNTERCLOCKWISE POSITION (AFC). ARROW INDICATES CLOCKWISE ROTATION AS VIEWED FROM FRONT PANEL.
2. ☆ VALUE VARIES WITH VOLTMETER INPUT RESISTANCE.

Figure 5-28. AFC/BFO Circuits and Output Amplifier

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts for the Model 302A, Wave Analyzer.

6-3. Table 6-1 lists replaceable parts in alpha-numerical order of their reference designators. Detailed information on a part used more than once in the instrument is listed opposite the first reference designator applying to the part. Other reference designators applying to the same part refer to the initial designator. Miscellaneous parts are included at the end of the list. Detailed information includes the following:

a. Reference designator.

b. Full description of the part.

c. Manufacturer of the part in a five-digit code; see list of manufacturers in appendix.

d. Hewlett-Packard stock number.

e. Total quantity used in the instrument (TQ col).

f. Recommended spare quantity for complete maintenance during one year of isolated service (RS col).

6-4. ORDERING INFORMATION.

6-5. To order a replacement part, address order or inquiry either to your authorized Hewlett-Packard sales representative or to

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California

or, in Western Europe, to

Hewlett-Packard S.A.
54-54bis Route Des Acacias
Geneva, Switzerland

6-6. Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designator.

d. Description.

6-7. To order a part not listed in table 6-1, give a complete description of the part and include its function and location.

Table 6-1. Replaceable Parts

Ckt Ref.	Description	Mfr	℗ Stock No.	TQ	RS		
C1, 2	Capacitor: variable, ceramic, 5-20 pf, 500 vdcw	72982	0130-0006	3	1		
C3	Capacitor: variable, ceramic, 7-45 pf, 500 vdcw	72982	0130-0001	2	1		
C4	Same as C1						
C5	Capacitor: fixed, mica, 270 pf ±10%, 500 vdcw	76433	0140-0015	2	1		
C6	Capacitor: fixed, mica, 1000 pf ±1%, 500 vdcw	00853	0140-0099	2	1		
C7	Capacitor: fixed, mica, 39 pf ±10%, 500 vdcw	00853	0140-0021	1	1		
C8	Same as C3						
C9	Capacitor: fixed, mica, 68 pf ±10%, 500 vdcw	00853	0140-0025	1	1		
C10, 11	Not assigned						

Table 6-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	℗ Stock No.	TQ*	RS*		
C12	Capacitor: fixed, mylar, 1 μf ±5%, 200 vdcw	84411	0170-0018	1	1		
C13	Capacitor: fixed, electrolytic, 10 μf -10% + 100%, 25 vdcw	56289	0180-0059	7	2		
C14	Capacitor: fixed, electrolytic, 1500 μf, 10 vdcw	56289	0180-0054	1	1		
C15	Capacitor: fixed, mica, 560 pf ±10%, 500 vdcw	00853	0140-0044	2	1		
C16	Same as C13						
C17	Capacitor: fixed, electrolytic, 100 μf, 12 vdcw	56289	0180-0039	3	1		
C18	Capacitor: fixed, electrolytic, 50 μf -10% + 100%, 25 vdcw	56289	0180-0058	3	1		
C19	Same as C17						
C20 thru C27	Not assigned						
C28	Same as C13						
C29,30	Capacitor: fixed, mica, 3300 pf ±10%, 500 vdcw	76433	0140-0029	3	1		
C31,32	Capacitor: fixed, electrolytic, 20 μf, 25 vdcw	56289	0180-0045	8	2		
C33	Capacitor: fixed, paper, 2 μf ±20%, 200 vdcw	82376	0160-0030	2	1		
C34,35	Capacitor: fixed, titanium dioxide, 6.8 pf ±5%, 500 vdcw	82142	0150-0043	2	1		
C36	Capacitor: variable, air, 2.7 - 19.6 pf	74970	0121-0028	1	1		
C37	Capacitor: variable, glass, 0.5 - 3 pf	07115	0133-0001	1	1		
C38	Capacitor: variable, air, 6 - 100.5 pf	80486	0121-0013	1	1		
C39	Part of Condenser Assembly; component not separately replaceable						
C40	Same as C33						
C41	Same as C13						
C42 thru C44	Not assigned						

* See introduction to this section

Table 6-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	℗ Stock No.	TQ*	RS*		
C45	Capacitor: variable, mica, 50 - 380 pf, 175 vdcw	72136	0131-0001	7	2		
C46	Capacitor: variable, mica, 170 - 780 pf, 175 vdcw	72136	0131-0003	9	2		
C47	Capacitor: fixed, mica, 0.017 μf ±2%, 300 vdcw Optimum value selected at factory Average value shown	72136	0140-0166	1	1		
C48	Same as C29 Optimum value selected at factory Average value shown						
C49, 50	Same as C46						
C51	Capacitor: fixed, mica, 820 pf ±10%, 500 vdcw	76433	0140-0010	1	1		
C52	Same as C45						
C53	Capacitor: fixed, mica, 180 pf ±10%, 500 vdcw	00853	0140-0023	1	1		
C54	Capacitor: fixed, mica, 680 pf ±10%, 500 vdcw	76433	0140-0007	3	1		
C55	Same as C46						
C56	Same as C45						
C57	Capacitor: fixed, mica, 150 pf ±10%, 500 vdcw	76433	0140-0055	1	1		
C58	Same as C45						
C59	Capacitor: fixed, mica, 220 pf ±10%, 500 vdcw Optimum value selected at factory Average value shown	00853	0140-0031	1	1		
C60	Same as C31						
C61	Capacitor: fixed, mylar, 0.22 μf ±10%, 200 vdcw	56289	0170-0038	13	2		
C62	Capacitor: fixed, mylar, 0.02 μf ±5%, 200 vdcw	84411	0170-0027	1	1		
C63, 64	Same as C61						
C65	Capacitor: fixed, titanium dioxide, 4.7 pf ±5%, 500 vdcw	82142	0150-0042	1	1		
C66	Same as C45						
C67	Capacitor: fixed, mylar, 0.047 μf ±10%, 200 vdcw	56289	0170-0040	1	1		

* See introduction to this section

Table 6-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	℗ Stock No.	TQ*	RS*		
C68	Same as C45						
C69	Same as C6 Optimum value selected at factory Average value shown						
C70	Same as C45						
C71, 72	Capacitor: fixed, mica, 100 pf ±10%, 500 vdcw C72 - Optimum value selected at factory. Average value shown	76433	0140-0054	2	1		
C73	Same as C46						
C74	Same as C31						
C75 thru C79	Same as C61						
C80	Capacitor: fixed, mica, 330 pf ±10%, 500 vdcw	00853	0140-0043	1	1		
C81 thru C85	Same as C61						
C86	Capacitor: fixed, mica, 4700 pf ±10%, 500 vdcw	00853	0140-0017	1	1		
C87	Same as C31						
C88	Capacitor: fixed, mica, 0.01 μf ±10%, 300 vdcw	00853	0140-0008	1	1		
C89	Same as C13						
C90	Same as C46						
C91	Capacitor: fixed, mica, 0.001 μf ±10%, 500 vdcw Optimum value selected at factory Average value shown	76433	0140-0003	1	1		
C92	Same as C13						
C93	Same as C46						
C94	Capacitor: fixed, mica, 470 pf ±10%, 500 vdcw Optimum value selected at factory Average value shown	76433	0140-0027	1	1		
C95	Same as C15						
C96	Same as C46						
C97	Same as C54 Optimum value selected at factory Average value shown						

* See introduction to this section

Table 6-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	℗ Stock No.	TQ*	RS*		
C98	Same as C5 Optimum value selected at factory Average value shown						
C99	Same as C46						
C100	Not assigned						
C101	Same as C31						
C102	Same as C13						
C103 thru C106	Not assigned						
C107	Same as C31						
C108	Same as C54						
C109 thru C117	Not assigned						
C118	Same as C31						
C119	Capacitor: fixed, electrolytic, 500 µf -10%, + 100%, 3 vdcw	56289	0180-0063	1	1		
C120	Capacitor: fixed, electrolytic, 1000 µf, 25 vdcw	56289	0180-0057	1	1		
C121	Same as C17						
C122	Capacitor: fixed, mylar, 0.1 µf ±5%, 200 vdcw	84411	0170-0019	1	1		
C123	Not assigned						
C124,125	Capacitor: fixed, electrolytic, 1000 µf, 50 vdcw	56289	0180-0056	2	1		
C126,127	Same as C18						
CR1,2	Diode, silicon	28480	G-29A-45	2	2		
CR3	Diode, silicon	28480	G-29A-74	2	2		
CR4,5	Capacitor: variable, voltage variable, -10 V, 100 pf ±20%, 20 vdcw	81483	0122-0001	2	2		
CR6,7	Diode, silicon: matched pair	28480	G-172E	1	1		
CR8 thru CR11	Diode, silicon: selected set of 4	28480	G-172F	1	1		

* See introduction to this section

Table 6-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	℗ Stock No.	TQ*	RS*		
CR12 thru CR16	Diode, germanium: 1N90	73293	1910-0004	9	9		
CR17, 18	Diode, silicon	73293	1901-0027	2	2		
CR19 thru CR22	Same as CR12						
CR23	Diode, silicon	28480	G-29A-26	1	1		
CR24,25	Diode, silicon	81483	1901-0007	2	2		
CR26	Diode, silicon	81483	1901-0008	1	1		
CR27	Same as CR3						
DS1	Lamp, neon: 1/25 W, NE2E	03797	1450-0037	1	1		
EQ1	Equalizer Network Assembly	28480	302A-27B	1	1		
F1	Fuse, cartridge: 1/8 amp, 250 V	75915	2110-0027	1	10		
FL1, 2	Filter	28480	302A-27A	2	1		
J1	Connector Assembly, consists of:						
	Binding post, black	28480	G-10C	1	1		
	Binding post, red	28480	G-10D	1	1		
	Insulator, black 2 hole	28480	G-83A-1	1	1		
J2	Jack, telephone: for 3 cond. plug	82389	1251-0070	1	1		
J3	Connector, BNC	91737	1250-0001	1	1		
J4	Connector Assembly, consists of:						
	Binding post, black	28480	G-10C	1	1		
	Binding post, red	28480	G-10D	1	1		
	Insulator, black 2 hole	28480	AC-54A	1	1		
	Insulator, black 1 hole	28480	AC-54D	1	1		
L1	Inductor, fixed: 5.5 mh	98405	9140-0002	1	1		
L2 thru L4	Not assigned						
L5	Inductor, fixed: 400 μh	99848	0140-0020	1	1		
L6	Inductor, variable: 600 μh	09250	9140-0012	1	1		
L7	Inductor: zero set	28480	302A-60F	1	1		
L8	Inductor, fixed: 200 μh	99848	9140-0019	1	1		
L9	Toroid Assembly: 2.78 mh	28480	302A-60H	1	1		

* See introduction to this section

Table 6-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	ⓗ Stock No.	TQ*	RS*		
L10 thru L12	Inductor, fixed: 500 μh	99848	9140-0022	5	1		
L13AB	Coil, recorder	28480	302A-60G	1	1		
L14	Same as L10						
L15	Inductor, fixed: 5 mh	98405	9140-0016	1	1		
L16	Same as L10						
L17 thru L19	Not assigned						
L20	Part of L9; component not separately replaceable						
M1	Meter	65092	1120-0005	1	1		
Q1	Transistor: specially selected for ⓗ type 1850-0011	28480	1850-0011	1	1		
Q2	Transistor: 2N582	02735	1850-0047	1	1		
Q3	Transistor: specially selected for ⓗ type 1850-0012	28480	1850-0012	1	1		
Q4, 5	Transistor: 2N650	04713	1850-0048	4	4		
Q6 thru Q16	Transistor: 2N274	02735	1850-0037	11	11		
Q17	Transistor: 2N218	02735	1850-0036	1	1		
Q18	Transistor: 2N169	03508	1851-0001	1	1		
Q19	Transistor: 2N525	03508	1850-0017	1	1		
Q20	Transistor: 2N301	02735	1850-0038	1	1		
Q21, 22	Same as Q4						
R1	Resistor: fixed, deposited carbon, 96,840 ohms ± 1%, 1 W	19701	0730-0067	1	1		
R2	Resistor: fixed, deposited carbon, 990,000 ohms ± 1%, 1/2 W	19701	0727-0271	1	1		
R3	Resistor: fixed, deposited carbon, 68,380 ohms ± 1%, 1 W	19701	0730-0056	1	1		
R4	Resistor: fixed, deposited carbon, 90,000 ohms ± 1%, 1 W	19701	0730-0064	1	1		
R5	Resistor: fixed, deposited carbon, 7842 ohms ± 1%, 1/2 W	19701	0727-0148	1	1		

* See introduction to this section

Table 6-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	℗ Stock No.	TQ*	RS*		
R6	Resistor: fixed, deposited carbon, 2250 ohms ±1%, 1/2 W	19701	0727-0120	1	1		
R7	Resistor: fixed, deposited carbon, 693.6 ohms ±1%, 1/2 W	19701	0727-0087	1	1		
R8	Resistor: fixed, deposited carbon, 217.4 ohms ±1%, 1/2 W	19701	0727-0057	1	1		
R9	Resistor: fixed, deposited carbon, 100 ohms ±1%, 1/2 W	19701	0727-0043	1	1		
R10	Resistor: fixed, deposited carbon, 3266 ohms ±1%, 1/2 W	19701	0727-0126	1	1		
R11	Resistor: fixed, deposited carbon, 46,250 ohms ±1%, 1/2 W	19701	0727-0191	1	1		
R12	Resistor: fixed, deposited carbon, 11,110 ohms ±1%, 1/2 W	19701	0727-0161	1	1		
R13	Resistor: fixed, composition, 6800 ohms ±10%, 1/2 W	01121	0687-6821	2	1		
R14	Resistor: fixed, deposited carbon, 4000 ohms ±1%, 1/2 W Optimum value selected at factory Average value shown	19701	0727-0132	1	1		
R15	Resistor: fixed, composition, 8200 ohms ±10%, 1/2 W	01121	0687-8221	4	1		
R16	Resistor: fixed, deposited carbon, 98,000 ohms ±1%, 1/2 W	19701	0727-0206	1	1		
R17	Resistor: fixed, metal film, 3000 ohms ±10%, 7 W	07115	0777-0001	1	1		
R18	Same as R15						
R19	Resistor: fixed, deposited carbon, 490 ohms ±1%, 1/2 W	19701	0727-0075	1	1		
R20	Resistor: variable, composition, 2500 ohms ±10%, 1/2 W	71590	2100-0067	1	1		
R21	Resistor: fixed, composition, 27,000 ohms ±5%, 1/2 W	01121	0686-2735	1	1		
R22	Resistor: fixed, deposited carbon, 3000 ohms ±1%, 1/2 W	19701	0727-0124	2	1		
R23	Resistor: fixed, composition, 22,000 ohms ±10%, 1/2 W	01121	0687-2231	6	2		
R24	Resistor: fixed, composition, 1800 ohms ±10%, 1/2 W	01121	0687-1821	2	1		

* See introduction to this section

Table 6-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	Stock No.	TQ*	RS*		
R25	Resistor: variable, composition, linear taper, 5000 ohms, 1/2 W	11237	2100-0011	1	1		
R26	Resistor: fixed, composition, 10,000 ohms ±10%, 1/2 W	01121	0687-1031	8	2		
R27	Resistor: fixed, composition, 150 ohms ±10%, 1/2 W	01121	0687-1511	1	1		
R28, 29	Resistor: fixed, composition, 2700 ohms ±10%, 1/2 W	01121	0687-2721	6	2		
R30	Resistor: fixed, deposited carbon, 790 ohms ±1/2%, 1/2 W	19701	0727-0091	1	1		
R31	Not assigned						
R32	Resistor: fixed, deposited carbon, 144 ohms ±1%, 1/2 W	19701	0727-0047	2	1		
R33	Resistor: fixed, deposited carbon, 2120 ohms ±1%, 1/2 W	19701	0727-0119	1	1		
R34	Same as R32						
R35	Resistor: fixed, deposited carbon, 2900 ohms ±1%, 1/2 W	19701	0727-0123	1	1		
R36	Resistor: fixed, deposited carbon, 83,000 ohms ±1%, 1/2 W	19701	0727-0202	1	1		
R37	Resistor: fixed, deposited carbon, 10,000 ohms ±1%, 1/2 W	19701	0727-0157	2	1		
R38	Resistor: fixed, deposited carbon, 52,600 ohms ±1%, 1/2 W	19701	0727-0196	1	1		
R39	Resistor: variable, composition, 250 ohms ±10%	01121	2100-0079	1	1		
R40	Same as R37						
R41	Resistor: fixed, composition, 5600 ohms ±10%, 1/2 W	01121	0687-5621	5	2		
R42	Resistor: fixed, composition, 1500 ohms ±10%, 1/2 W	01121	0687-1521	2	1		
R43	Resistor: fixed, deposited carbon, 3600 ohms ±1%, 1/2 W	19701	0727-0128	1	1		
R44	Resistor: fixed, wirewound, 1500 ohms ±1%, 5 W	91637	0811-0005	4	1		
R45	Resistor: variable, wirewound, 100 ohms ±10%, 2 W	11237	2100-0003	1	1		

* See introduction to this section

Table 6-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	Stock No.	TQ*	RS*		
R46 thru R48	Same as R44						
R49	Resistor: fixed, composition, 180 ohms ±10%, 1/2 W	01121	0687-1811	2	1		
R50	Resistor: fixed, composition, 47 ohms ±10%, 1/2 W	01121	0687-4701	1	1		
R51	Resistor: fixed, composition, 120 ohms ±10%, 1/2 W Optimum value selected at factory Average value shown	01121	0687-1211	2	1		
R52, 53	Resistor: fixed, composition, 18 ohms ±10%, 1/2 W	01121	0687-1801	2	1		
R54, 55	Not assigned						
R56	Resistor: fixed, deposited carbon, 26,700 ohms ±1%, 1/2 W	19701	0727-0183	1	1		
R57, 58	Resistor: fixed, composition, 100 ohms ±10%, 1/2 W Optimum value selected at factory Average value shown	01121	0687-1011	3	1		
R59	Resistor: fixed, deposited carbon, 1470 ohms ±1%, 1/2 W	19701	0727-0109	1	1		
R60	Not assigned						
R61 thru R65	Resistor: fixed, wirewound, 721.9 ohms	28480	302A-26B	5	2		
R66	Resistor: fixed, wirewound, 493.6 ohms	28480	302A-26A	1	1		
R67 thru R72	Resistor: fixed, wirewound, 1067 ohms	28480	302A-26C	6	2		
R73	Resistor: fixed, composition, 27,000 ohms ±10%, 1/2 W	01121	0687-2731	3	1		
R74	Same as R51						
R75	Resistor: fixed, composition, 12,000 ohms ±10%, 1/2 W	01121	0687-1231	1	1		
R76	Same as R13						
R77	Resistor: fixed, deposited carbon, 5.77 ohms ±1/2%, 1/2 W	19701	0727-0005	1	1		
R78	Same as R41						
R79	Same as R23						

* See introduction to this section

Table 6-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	℗ Stock No.	TQ*	RS*		
R80	Same as R15						
R81	Resistor: fixed, deposited carbon, 201 ohms ±1%, 1/2 W	19701	0727-0055	2	1		
R82	Same as R24						
R83	Same as R22 Optimum value selected at factory Average value shown						
R84	Not assigned						
R85	Same as R23						
R86	Same as R41						
R87	Same as R26						
R88	Resistor: fixed, composition, 3900 ohms ±10%, 1/2 W	01121	0687-3921	1	1		
R89	Resistor: fixed, composition, 220 ohms ±10%, 1/2 W	01121	0687-2211	2	1		
R90	Resistor: fixed, deposited carbon, 37.35 ohms ±1/2%, 1/2 W	19701	0727-0017	1	1		
R91	Same as R28						
R92	Resistor: variable, composition, linear taper, 2500 ohms ±20%, 0.3 W	11237	2100-0196	1	1		
R93	Same as R26						
R94	Resistor: fixed, composition, 33,000 ohms ±10%, 1/2 W	01121	0687-3331	1	1		
R95	Resistor: fixed, composition, 270 ohms ±10%, 1/2 W	01121	0687-2711	2	1		
R96	Same as R41						
R97	Same as R26						
R98	Same as R28						
R99	Resistor: fixed, deposited carbon, 150 ohms ±1%, 1/2 W Optimum value selected at factory Average value shown	19701	0727-0048	1	1		
R100,101	Resistor: fixed, composition, 10 ohms ±10%, 1/2 W	01121	0687-1001	2	1		
R102	Same as R23						

* See introduction to this section

Table 6-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	℗ Stock No.	TQ*	RS*		
R103	Same as R41						
R104	Resistor: fixed, composition, 2200 ohms ±10%, 1/2 W	01121	0687-2221	2	1		
R105	Resistor: fixed, composition, 560 ohms ±10%, 1/2 W	01121	0687-5611	1	1		
R106	Not assigned						
R107	Resistor: fixed, composition, 470 ohms ±10%, 1/2 W	01121	0687-4711	1	1		
R108	Same as R49 Optimum value selected at factory Average value shown						
R109	Same as R81						
R110	Resistor: fixed, composition, 56 ohms ±10%, 1/2 W	01121	0687-5601	1	1		
R111	Resistor: variable, wirewound, 300 ohms	11237	2100-0038	1	1		
R112	Resistor: fixed, composition, 1200 ohms ±10%, 1/2 W	01121	0687-1221	1	1		
R113	Same as R26						
R114	Resistor: fixed, composition, 330 ohms ±10%, 1/2 W	01121	0687-3311	1	1		
R115	Same as R28						
R116	Resistor: variable, wirewound, 50 ohms ±10%, 2 W	11237	2100-0002	1	1		
R117	Resistor: fixed, composition, 1000 ohms ±10%, 1/2 W	01121	0687-1021	3	1		
R118,119	Not assigned						
R120	Resistor: fixed, composition, 82,000 ohms ±10%, 1/2 W	01121	0687-8231	1	1		
R121	Same as R23						
R122	Resistor: variable, composition, 50,000 ohms ±10%	01121	2100-0028	1	1		
R123	Resistor: fixed, composition, 100,000 ohms ±10%, 1/2 W	01121	0687-1041	3	1		
R124 thru R128	Not assigned						

* See introduction to this section

Table 6-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	℗ Stock No.	TQ*	RS*		
R129	Resistor: variable, composition, linear taper, 5000 ohms ±10%	01121	2100-0026	2	1		
R130	Same as R73						
R131	Same as R129						
R132	Same as R73						
R133	Same as R104						
R134	Same as R26						
R135	Same as R42						
R136,137	Same as R117						
R138	Not assigned						
R139	Resistor: fixed, composition, 820 ohms ±10%, 1/2 W	01121	0687-8211	1	1		
R140	Not assigned						
R141	Resistor: fixed, composition, 36,000 ohms ±5%, 1/2 W	01121	0686-3635	1	1		
R142	Same as R26						
R143	Resistor: fixed, composition, 18,000 ohms ±10%, 1/2 W	01121	0687-1831	1	1		
R144	Resistor: fixed, composition, 9100 ohms ±5%, 1/2 W	01121	0686-9125	1	1		
R145	Same as R57						
R146	Same as R15						
R147	Same as R26						
R148	Resistor: fixed, composition, 4700 ohms ±10%, 1/2 W	01121	0687-4721	2	1		
R149	Resistor: variable, composition, linear taper, 600 ohms ±10%, 1/2 W	11237	2100-0223	1	1		
R150	Same as R95						
R151	Same as R89						
R152	Same as R123						
R153	Same as R28						
R154	Same as R23						

* See introduction to this section

Table 6-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	℗ Stock No.	TQ*	RS*		
R155	Resistor: fixed, composition, 100 ohms ±10%, 1 W	01121	0690-1011	1	1		
R156	Resistor: fixed, composition, 3300 ohms ±10%, 1/2 W	01121	0687-3321	3	1		
R157	Same as R123						
R158	Same as R148						
R159	Same as R156						
R160	Resistor: variable, composition, linear taper, 2000 ohms ±20%, 1/3 W	11237	2100-0153	1	1		
R161	Same as R156						
S1ABC	Switch, rotary: 3 section, 9 position	76854	3100-0194	1	1		
S2A	Switch, rotary	76854	3100-0196	1	1		
S2B	Switch	28480	302A-19C	1	1		
S3ABC	Switch, rotary	76854	3100-0193	1	1		
S4	Switch, toggle: DPST	88140	3101-0003	1	1		
S5	Switch, slide: DPDT	42190	3101-0011	1	1		
S6	Switch, toggle: SPDT	04009	3101-0025	1	1		
T1	Oscillator Coil Assembly	28480	302A-60A	1	1		
T2	Transformer, oscillator drive	28480	9120-0041	1	1		
T3	Transformer, oscillator output	98734	9120-0040	1	1		
T4	Transformer, IF input	98734	9120-0044	1	1		
T5	Transformer, IF filter output	98734	9120-0043	1	1		
T6	Transformer, limiter input	98734	9120-0046	1	1		
T7	Transformer, limiter output	98734	9120-0042	1	1		
T8	Transformer, frequency restorer modulator input	98734	9120-0038	1	1		
T9	Transformer, frequency modulator output	98734	9120-0039	1	1		
T10	Transformer, power	98734	9100-0107	1	1		

* See introduction to this section

Table 6-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	Stock No.	TQ*	RS*		
Y1 thru Y4	Crystal: matched set of 4	28480	G-171A	1	1		
	MISCELLANEOUS						
	Holder, fuse	75915	1400-0084	1	1		
	Knob: ZERO SET	28480	G-74F	1	0		
	Knob: AMPLITUDE	28480	G-74G	1	0		
	Knob: MODE SELECTOR	28480	G-74N	1	0		
	Knob: RANGE	28480	G-74P	1	0		
	Knob: MAX. INPUT VOLTAGE	28480	G-74Q	1	0		
	Knob: REF ADJUST	28480	G-74AV	1	0		
	Knob: COARSE	28480	G-74R	1	0		
	Knob: FINE	28480	G-74BV	1	0		
	Condenser Assembly, consists of: C37 thru C39, CR4, CR5, L6, L7, T1	28480	302A-7C	1	1		

* See introduction to this section

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

CODE NO.	MANUFACTURER	ADDRESS
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00853	Sangamo Electric Co., Cap. Div.	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Semiconductor Components Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Special Tube Operations of Sylvania Electronic Systems	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Division	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05624	Barber Colman Co.	Rockford, Ill.
05729	Metropolitan Telecommunications Corp., Metro Cap. Div.	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Soquel, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06812	Torrington Mfg. Co., West. Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12697	Clarostat Mfg. Co.	Dover, N.H.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G. E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G. E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C. A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Mfg. Co.	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Div. of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio

From: F.S.C. Handbook Supplements
H4-1 Dated April 1961
H4-2 Dated April 1961

00015-16
Revised: 20 September 1961

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	Industrial Products Co.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Mfg. Co., Inc.	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Chicago, Ill.
77068	Bendix Corp., Bendix Pacific Div.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77342	Potter and Brumfield, Inc.	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77634	Radio Essentials Inc.	Mt. Vernon, N.Y.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W. L. Maxson Corp.	Wallingford, Conn.
80248	Oxford Electric Corp.	Chicago, Ill.
80411	Acro Manufacturing Co.	Columbus, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Tube Division	Quincy, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Texas Instruments, Inc., Metals and Controls Div., Spencer Products	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Products, Inc.	Columbus, Neb.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Micro-Switch Div. of Minneapolis Honeywell Regulator Co.	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Receiving Tube Div.	Quincy, Mass.
94145	Raytheon Mfg. Co., Semi-conductor Div.	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	Carlstadt, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95354	Methode Mfg. Co.	Chicago, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96493	J. W. Miller Co.	Los Angeles, Calif.
96501	Excel Transformer Co.	Oakland, Calif.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	New Rochelle, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99821	North Hills Electric Co.	Great Neck, L.I., N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics, Corp.	Evanston, Ill.
99957	Technology Instruments Corp. of Calif.	No. Hollywood, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

0000C	Connor Spring Mfg. Co.	San Francisco, Calif.
0000F	Malco Tool and Die	Los Angeles, Calif.
0000H	Philco Corp. (Lansdale Division)	Lansdale, Pa.
0000I	Telefunken (c/o American Elite)	New York, N.Y.
0000L	Winchester Electronics, Inc.	Santa Monica, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000T	Texas Instruments, Inc. Metals and Controls Div.	Versailles, Ky.
0000U	Tower Mfg. Corp.	Providence, R.I.
0000V	Imperial Electronics, Inc.	Buena Park, Calif.
0000W	Webster Electronics Co. Inc.	New York, N.Y.
0000X	Spruce Pine Mica Co.	Spruce Pine, N.C.
0000Y	Midland Mfg. Co. Inc.	Kansas City, Kans.
0000Z	Willow Leather Products Corp.	Newark, N.J.

From: F.S.C. Handbook Supplements
H4-1 Dated April 1961
H4-2 Dated April 1961

00015-16
Revised: 20 September 1961

MANUAL CHANGES

MODEL 302A

WAVE ANALYZER

Manual printed: 1-61
For Serials Prefixed: 018-

ERRATA in the Table of Replaceable Parts, under MISCELLANEOUS:

Fuseholder: Change -hp- Stock No. to read 1400-0084.

CR17,18: Change -hp- Stock No. to read 1901-0027.

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
018-	ERRATA		
ALL	1		
249-	1, 2, ERRATA		
305-	1, 2, 3, ERRATA		

CHANGE 2 (cont)

Table 6-1, Replaceable Parts,

Delete: S6

Add: S7, switch, slide, DPDT; ⓗⓟ Stock No. 3101-0033.

CHANGE 3

C69: Change to capacitor, fixed, mica 1800 pf; ⓗⓟ Stock No. 0140-0020.
C91: Change to capacitor, fixed, mica 1800 pf ±10%; ⓗⓟ Stock No. 0140-0020.
CR1, CR2: Change to diode, silicon; ⓗⓟ Stock No. 1901-0033.
CR23: Change to diode, silicon; ⓗⓟ Stock No. 1902-0052.

MANUAL CHANGES

MODEL 302A

WAVE ANALYZER

Manual Serial Prefixed: 018-
Manual Printed: 11/61

To adapt this manual to instruments with other serial prefixes check for errata below, and make changes shown in tables.

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
018-	ERRATA		
ALL	1		
249-	1, 2, ERRATA		
305-	1, 2, 3, ERRATA		

ERRATA:

Paragraph 5-12, Lines 4 and 5,
Change to read: "..... Change line fuse to a 1/16 ampere slow-blow fuse when changing from 115 volt to 230 volt operation."

Table 6-1,
Add F1: Fuse, cartridge, 1/16 amp, slow-blow, (for 230 volt operation); ⓗ Stock No. 2110-0040; Mfr. 75915.

Figure 3-5,
The line from the 3/6 callout should go to the RANGE switch (window) control.

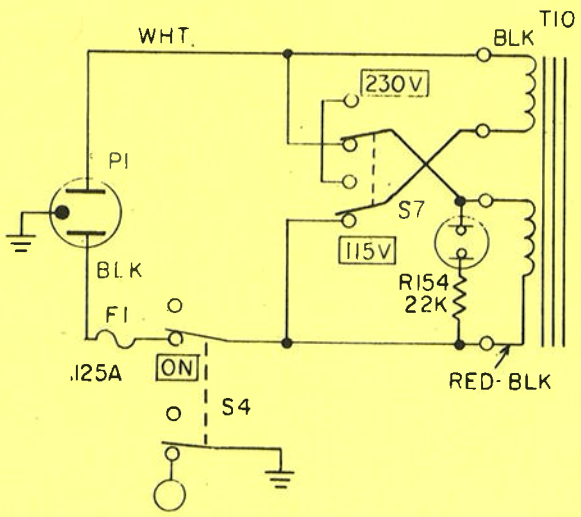
Figure 5-1, Front Panel Performance Check,
Delete cable from OUTPUT to INPUT connectors.

CHANGE 1

Table 6-1,
Q1, Q3: Change to transistor, 2N404; ⓗ Stock No. 1850-0062.
CR24, 25: Change to diode, silicon; ⓗ Stock No. 1901-0028.
CR26: Change to diode, silicon; ⓗ Stock No. 1901-0026.

CHANGE 2

Figure 5-25,
Change as shown in the following partial schematic:



WARRANTY

All our products are warranted against defects in materials and workmanship for one year from the date of shipment. Our obligation is limited to repairing or replacing products (except tubes) which prove to be defective during the warranty period. We are not liable for consequential damages.

For assistance of any kind, including help with instruments under warranty, contact your authorized hp Sales Representative for instructions. Give full details of the difficulty and include the instrument model and serial numbers. Service data or shipping instructions will be promptly sent to you. There will be no charge for repair of instruments under warranty, *except transportation charges*. Estimates of charges for non-warranty or other service work will always be supplied, if requested, before work begins.

CLAIM FOR DAMAGE IN SHIPMENT

Your instrument should be inspected and tested as soon as it is received. The instrument is insured for safe delivery. If the instrument is damaged in any way or fails to operate properly, file a claim with the carrier or, if insured separately, with the insurance company.

SHIPPING

On receipt of shipping instructions, forward the instrument prepaid to the destination indicated. You may use the original shipping carton or any strong container. Wrap the instrument in heavy paper or a plastic bag and surround it with three or four inches of shock-absorbing material to cushion it firmly and prevent movement inside the container.

GENERAL

Your authorized hp Sales Representative is ready to assist you in any situation, and you are always welcome to get directly in touch with Hewlett-Packard service departments:

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